A revision of Charopidae with a finely cancellate protoconch sculpture from mid-eastern Queensland (Eupulmonata: Charopidae)

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ABSTRACT

This study reviews the charopid land snails of mid-eastern Queensland possessing finely cancellate sculpture on the protoconch. Microscopic features of shell sculpture and qualitative and quantitative measurements of conchological features are utilised to delimit species due to lack of animal material suitable for DNA analysis. This study confirms the generic status of *Pereduropa* Stanisic, 2010 and *Isolderopa* Stanisic, 2010 and expands the brief descriptions of the species previously described in these genera. One new species of *Pereduropa, P. burwelli* sp. nov. and three new species of *Isolderopa* viz. *I. teemburra* sp. nov., *I. diamante* sp. nov. and *I. whitsunday* sp. nov. are described. A new genus, *Tristanoropa* gen. nov., is diagnosed for two new species *T. hughesae* sp. nov. and *T. conwayensis* sp. nov.

❒ *Mollusca, Eupulmonata, Charopidae, protoconch sculpture, finely cancellate, new genera, new species.*

Charopids are tiny land snails and their size (shell diameter 1-7 mm) and often cryptic habitat make them difficult to find alive and as a result they are generally collected as dead shells from leaf litter sorting. Consequently, identification of charopid species and their assignment to genera has required a strong emphasis on shell morphology and in particular, protoconch sculptural patterns (Hyman & Stanisic 2005; Shea *et al.* 2012; Stanisic 2016; Holcroft 2018a). This study reviews the charopid land snails of mid-eastern Queensland possessing finely cancellate protoconchs and is part of a larger revision of the Charopidae (Pinwheel Snails) of mid-eastern Queensland (Holcroft 2018b).

The eastern Australian charopids have been shown to possess eleven major protoconch sculptural patterns formed by a combination of spiral cords and radial ribs (Holcroft 2018a). The finely cancellate sculptural pattern is one where narrow, raised spiral cords or threads and narrow, raised radial ribs of similar dimensions combine to give a net-like appearance when viewed under scanning electron microscopy (SEM). Personal observation reveals this pattern is more prevalent in the smallest of the Australian charopids (those with a shell diameter less than 2.6 mm) currently assigned to *Rotacharopa* Stanisic, 1990, *Pereduropa* Stanisic, 2010, *Isolderopa* Stanisic, 2010, *Excaliburopa* Stanisic, 2010, *Shearopa* Stanisic, 2010 and *Ygernaropa* Stanisic, 2010. Within this baseline pattern, there are a number of variations such as 'scalloped' and 'webbed' which further define individual genera.

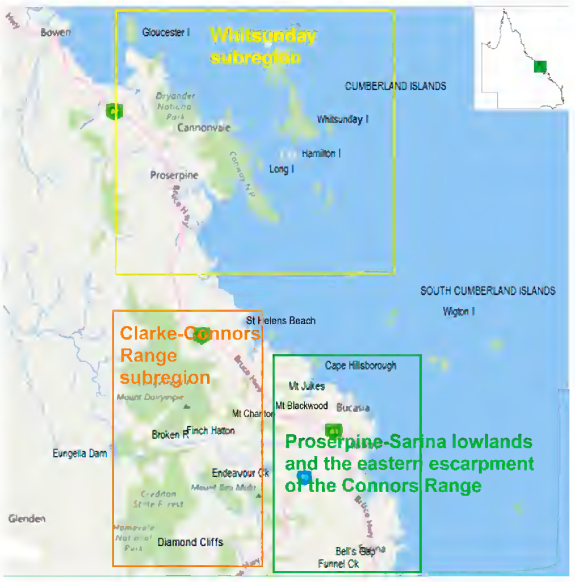


FIG. 1. Mid-eastern Queensland showing major collection areas.

In this study, six described and six newly described species of charopid from mid-eastern Queensland (Fig. 1) are shown to have a finely cancellate protoconch sculpture. All are tiny and less than 2.6 mm in shell diameter. Stanisic *et al.* (2010) introduced two genera with nautiloid coiling patterns to incorporate the six described species mentioned above. *Pereduropa* comprised minute charopids with a brown shell and a slightly elevated spire. In contrast, *Isolderopa* included minute charopids with a brown, biconcave shell, a depressed to very depressed spire and in two species, apertural barriers. Apertural barriers appear shortly after hatching and are added to anteriorly and reabsorbed posteriorly during subsequent growth (Solem 1983: 15) and at times disappear altogether in adulthood (Stanisic pers. comm.). This character is not a feature of any *Pereduropa* species.

Four new species belonging to these genera, *P. burwelli* sp. nov., *I. teemburra* sp. nov., *I. diamante* sp. nov. and *I. whitsunday* sp. nov. are described. *Tristanoropa* gen. nov., is diagnosed for two new species with finely cancellate protoconchs and a multi-whorled coiling pattern, viz. *T. hughesae* sp. nov. and *T. conwayensis* sp. nov.

Abbreviations. General: SEM, scanning electron microscopy; SC, spirit collection; RC, dry collection. Institutions: AM, Australian Museum, Sydney; QM, Queensland Museum, Brisbane. Habitat Data: alt, altitude; Ck, Creek; cnvf, complex notophyll vine forest; Hts, Heights; I., Island; MEQ, Mid-eastern Queensland; Mt, Mountain; Mts, Mountains; NENSW, North-eastern New South Wales; NEQ, North-eastern Queensland; NP, National Park; NSW, New South Wales; nvf, notophyll vine forest; R, River; Ra, Range; SEQ, South-eastern Queensland; sevt, semi-evergreen vine thicket; SF, State Forest; WT, Wet Tropics. Shell features: AH, aperture height; AW, aperture width; D, shell diameter; D/U, ratio of shell diameter to umbilical width; H, shell height; H/D, ratio of shell height to shell diameter; PD, protoconch diameter; PL, protoconch length; T1, 1st whorl of the teleoconch; U, umbilical width; WWB, number of ribs on the 3rd quarter of the body whorl.

MATERIALS AND METHODS

The study was chiefly based on material held in the Queensland (Brisbane) and Australian (Sydney) Museums. Individual specimens are identified by their registration number and respective institutional prefix (QMMO, Queensland Museum; AMSC, Australian Museum). Undescribed species in the collections of these museums are identified by a family descriptor and an alpha-numeric codon e.g. Charopid WT 41.

Adult shells were measured using a Camera Lucida mounted on a WILD M5 stereo microscope. Measurements were converted from ocular micrometre units to mm using a conversion factor at a set magnification. Characters investigated included shell shape, size (height and diameter), whorl count, coiling pattern, protoconch diameter, protoconch whorl length, rib count and umbilical width. Standard definitions (Solem 1983) for most conchological characters were used and whorl counts were made to the nearest 1/8 whorl.

High resolution images of shells (260-600MB) were obtained using a Visionary Digital BK-Plus

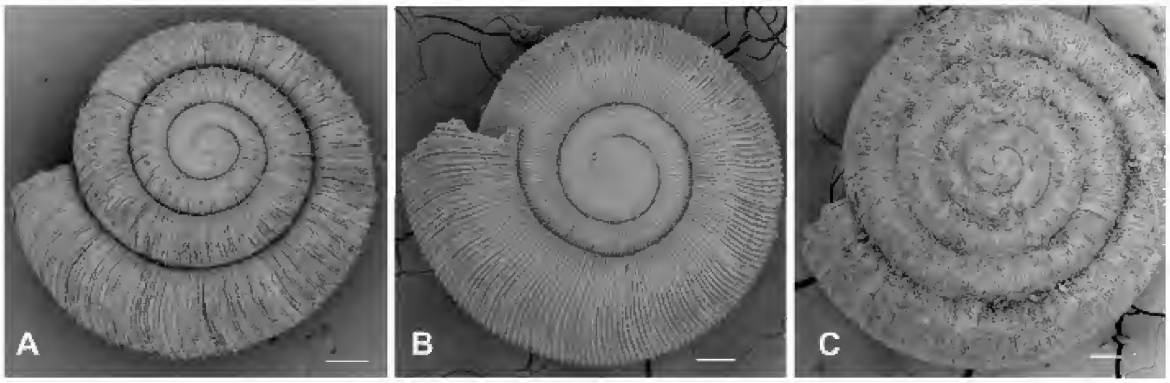


FIG. 2. Coiling patterns of the finely cancellate genera of MEQ. **A,** Nautiloid shell with flat spire of *Pereduropa* (*P. cursacosta* sp. nov., QMMO11901, Cape Hillsborough); **B,** Nautiloid shell with depressed spire of *Isolderopa* (*I. whitsunday* sp. nov., QMMO11902, Cape Hillsborough); **C,** Multi-whorled shell of *Tristanoropa* gen. nov. (*T. hughesae* sp. nov., QMMO50887, Eungella NP). Scale bars = 100µm.

lab system camera set-up in the Queensland Museum's Digital Imaging Unit.

The shell sculpture of specimens was investigated and photographed using a TM-1000 Tabletop Scanning Electron Microscope located at the Queensland Museum. Shells were cleaned in an ultrasonic cleaner but not by chemical means in order to prevent the removal of the periostracum which protects many of the shell's sculptural elements. Specimens were mounted on sticky tabs, gold sputter coated and imaged under high vacuum. Sculptural patterns of both the protoconch and teleoconch were extensively examined.

RESULTS

Shell morphology

Shell coiling patterns. Protoconch sculpture has been increasingly used to define charopid genera (Solem 1983; Stanisic 1990, 1998; Hyman & Stanisic 2005; Shea *et al.* 2012). However other morphological features of shells can be used in conjunction with this character (Solem 1983). In this study, where all species have a finely cancellate protoconch, other shell characters have been used. When the protoconch pattern is similar across genera, shell coiling pattern and spire protrusion play a significant role in the delimitation of genera. Both nautiloid and multi-whorled forms are evident within MEQ charopids. *Pereduropa* has an evenly coiled nautiloid form with a flat to raised spire (Fig. 2A), *Isolderopa* has a more tightly coiled, laterally compressed, nautiloid form with a depressed spire (Fig. 2B) and *Tristanoropa* gen. nov. has a tightly multi-whorled shell where the body whorl does not flare as in the previous two genera (Fig. 2C).

Shell measurements. Means of the shell measurements of all species examined in this study are shown in Table 1 and measurements of all individual specimens are tabulated in the Appendix. Within *Pereduropa* all species were differentiated by the protoconch diameter and the number of ribs on the first whorl of the teleoconch. *Pereduropa burwelli* sp. nov. was distinguished from other *Pereduropa* spp. by a large D/U ratio, a larger protoconch diameter and greater number of ribs on the first whorl of the teleoconch than the previously described species.

Isolderopa species shared a similar protoconch diameter with the exception of one species, *I. minuta* Stanisic, 2010, which had an unusually tiny protoconch diameter of 250 µm, a much smaller shell diameter and much finer ribbing on the teleoconch. The aperture height and width of *I. iangallowayi* Stanisic, 2010, in addition to its tighter coiling, distinguishes

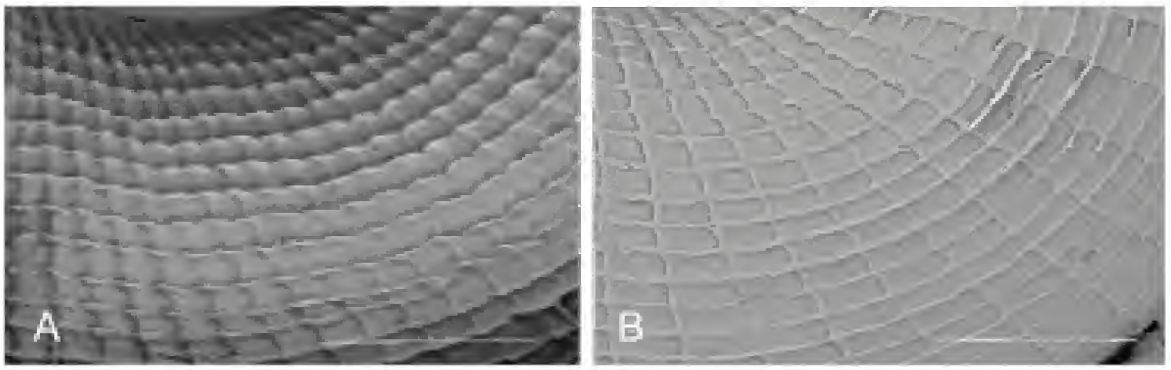


FIG. 3. Finely cancellate protoconch sculptural variations. **A,** Scalloped variant of *Isolderopa iangallowayi,* QMMO85080, Pelion SF, MEQ; **B,** Webbed variant of Charopid SQ78, QMMO13463, Biloela, SEQ. Scale bars = 50 µm.

this species from its congeners. D/U ratios differentiate *I. deliqua* Stanisic, 2010, *I. teemburra* sp. nov. and *I. whitsunday* sp. nov. from each other. *Isolderopa diamante* sp. nov. though larger in shell diameter than *I. minuta,* was much smaller in this measurement and D/U ratio than its congeners. The form and number of apertural barriers is also important in distinguishing the species in this genus.

Protoconch diameter, teleoconch ribbing and the D/U ratio separate the two new species in *Tristanoropa* gen. nov. Protoconch diameter varied between the two species: *T. hughesae* sp. nov. 410 µm and *T. conwayensis* sp. nov. a smaller diameter of 330 µm. However,

TABLE 1. Mean shell measurements of MEQ species examined in this study. New species are designated in bold type.

Taxon	n	D (mm)	H (mm)	UW (mm)	AH (mm)	AW (mm)	PD (mm)	WWB	T1	H/D ratio	D/U ratio	No. whorls	PL
Pereduropa cursacosta	8	2.36	1.34	0.82	0.94	0.86	0.41	29	50	0.57	2.89	4.17	1.50
Pereduropa delicata	7	2.01	1.11	0.75	0.85	0.75	0.41	30	73	0.55	2.73	4.39	1.52
Pereduropa hamiltoniana	6	1.90	1.08	0.64	0.83	0.66	0.41	17	44	0.57	2.97	4.31	1.56
Pereduropa burwelli	13	2.21	1.24	0.66	0.98	0.83	0.49	37	93	0.56	3.37	4.22	1.66
Isolderopa iangallowayi	14	1.86	1.16	0.70	1.02	0.70	0.33	49	104	0.62	2.68	5.15	1.69
Isolderopa minuta	10	1.41	0.82	0.65	0.70	0.50	0.25	59	124	0.58	2.18	4.42	1.66
Isolderopa deliqua	11	1.95	1.10	0.80	0.91	0.65	0.33	38	100	0.57	2.43	4.41	1.63
Isolderopa teemburra	3	1.97	1.12	0.93	0.87	0.68	0.33	45	119	0.57	2.12	4.42	1.71
Isolderopa whitsunday	11	1.66	0.86	0.70	0.74	0.46	0.33	53	118	0.52	2.40	4.51	1.54
Isolderopa diamante	7	1.55	0.93	0.67	0.82	0.57	0.33	39	108	0.60	2.32	3.98	1.68
Tristanoropa conwayensis	8	1.73	1.02	0.67	0.73	0.63	0.33	35	79	0.59	2.62	4.62	1.53
Tristanoropa hughesae	7	1.66	0.94	0.64	0.76	0.63	0.41	55	109	0.57	2.59	4.74	1.52

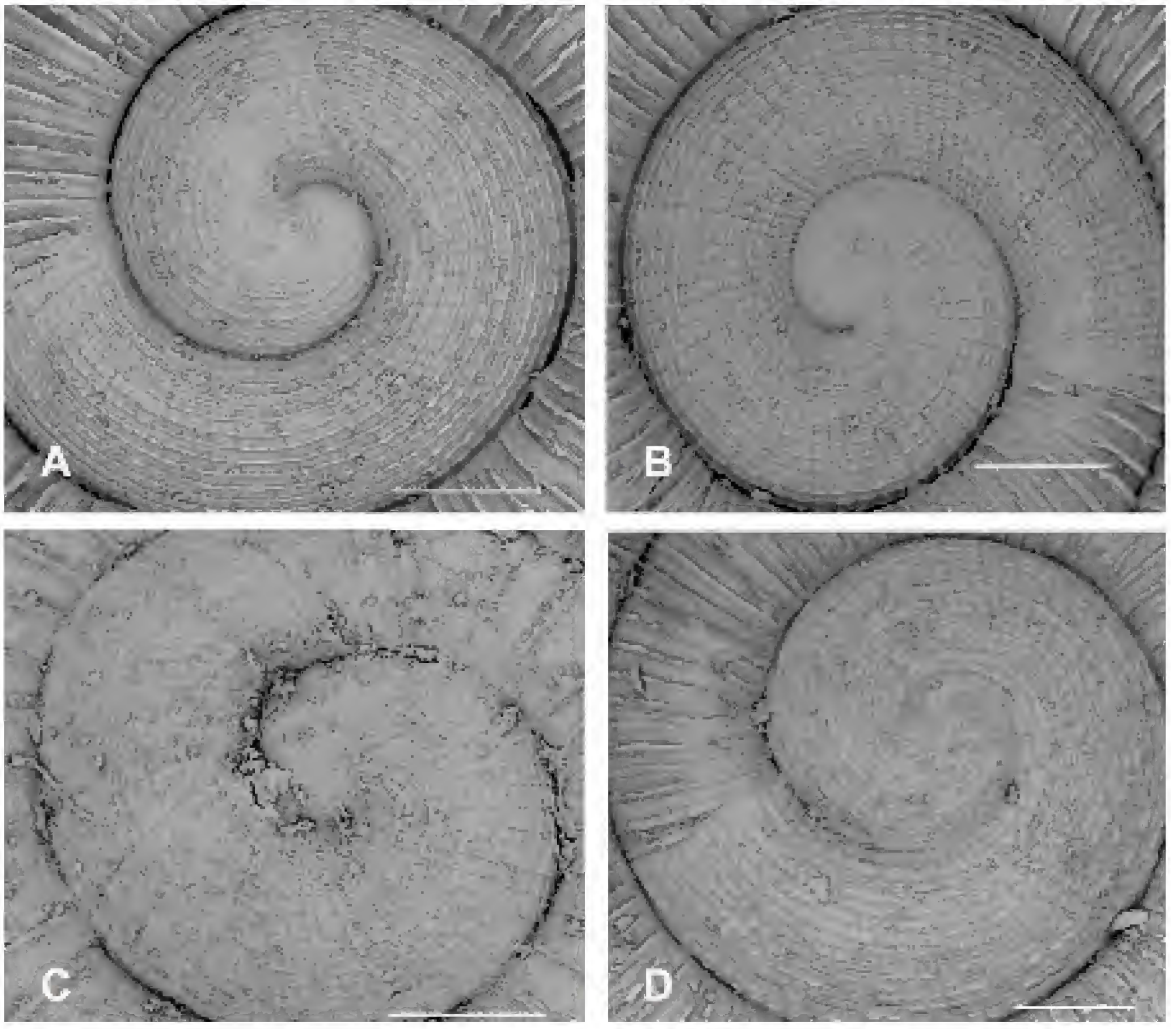


FIG. 4. Protoconch sculpture of *Pereduropa* species. **A,** *P. cursacosta*, QMMO85129, Jaxut SF, MEQ; **B,** *P. delicata*, AMSC154896, Mt Dryander, MEQ; **C,** *P. hamiltoniana*, QMMO86089, Hamilton I., MEQ; **D,** *P. burwelli* sp. nov., QMMO6369, Dalrymple Hts, MEQ. Scale bars = 100 µm.

the number of ribs on the first whorl of the teleoconch (*T. hughesae* sp. nov. mean 110 ribs, *T. conwayensis* sp. nov. mean 79 ribs) reveals a marked difference between the species.

Shell sculpture. SEM images confirmed that finely cancellate was the baseline protoconch sculptural pattern of all species. A detailed study of the MEQ and other species from the WT and SEQ with finely cancellate protoconchs showed two major variations of this sculpture (Fig. 3): 1, a pattern where the protoconch exhibited spiral cords only for the first quarter of a whorl followed by these spirals appearing 'bladed' and rising over radial ribs dropping down immediately following the ribs giving the appearance of a 'scalloped' pattern; and 2, a variation was formed by spiral cords and radial ribs of similar heights intersecting to give a netlike appearance. The 'scalloped' variation of a finely cancellate protoconch sculpture was found in each species of the three genera, *Pereduropa*, *Isolderopa* and *Tristanoropa*.

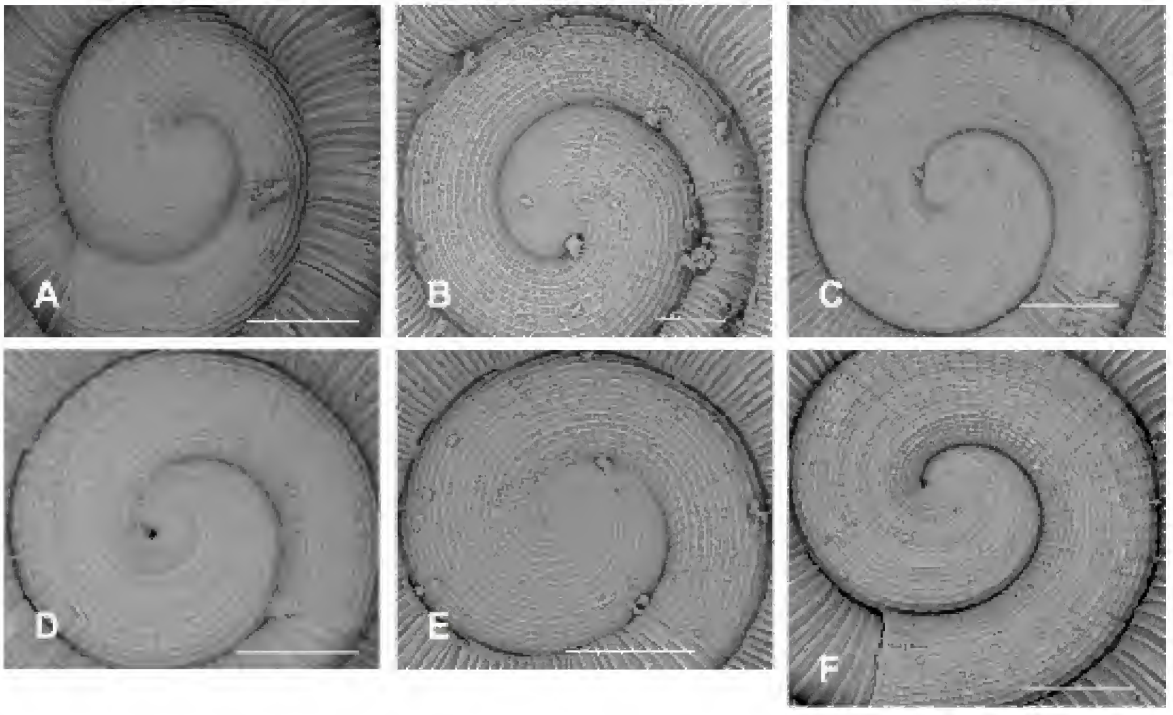


FIG. 5. Protoconch sculpture of *Isolderopa* species. **A,** *I. iangallowayi*, QMMO85131, Mt Charlton, MEQ; **B,** *I. minuta*, QMMO78980, Eungella NP, MEQ; **C,** *I. deliqua*, QMMO78963, Calen-Mt Charlton Rd, MEQ; **D,** *I. teemburra* sp. nov., QMMO35809, Endeavour Ck, MEQ; **E,** *I. whitsunday* sp. nov., QMMO11902, Cape Hillsborough, MEQ; **F,** *I. diamante* sp. nov., QMMO77078, Diamond Cliffs, MEQ. Scale bars = 100 µm.

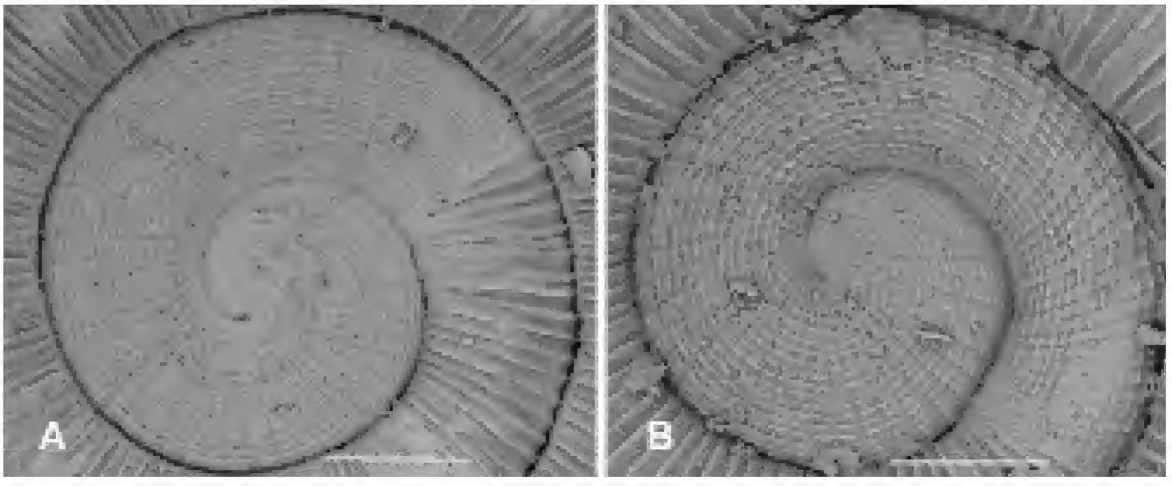


FIG. 6. Protoconch sculpture of *Tristanoropa* gen. nov. species. **A,** *T. hughesae* sp. nov., QMMO85136, Mt Charlton, MEQ; **B,** *T. conwayensis* sp. nov., AMSC154891, Brandy Creek, MEQ. Scale bars = 100 µm.

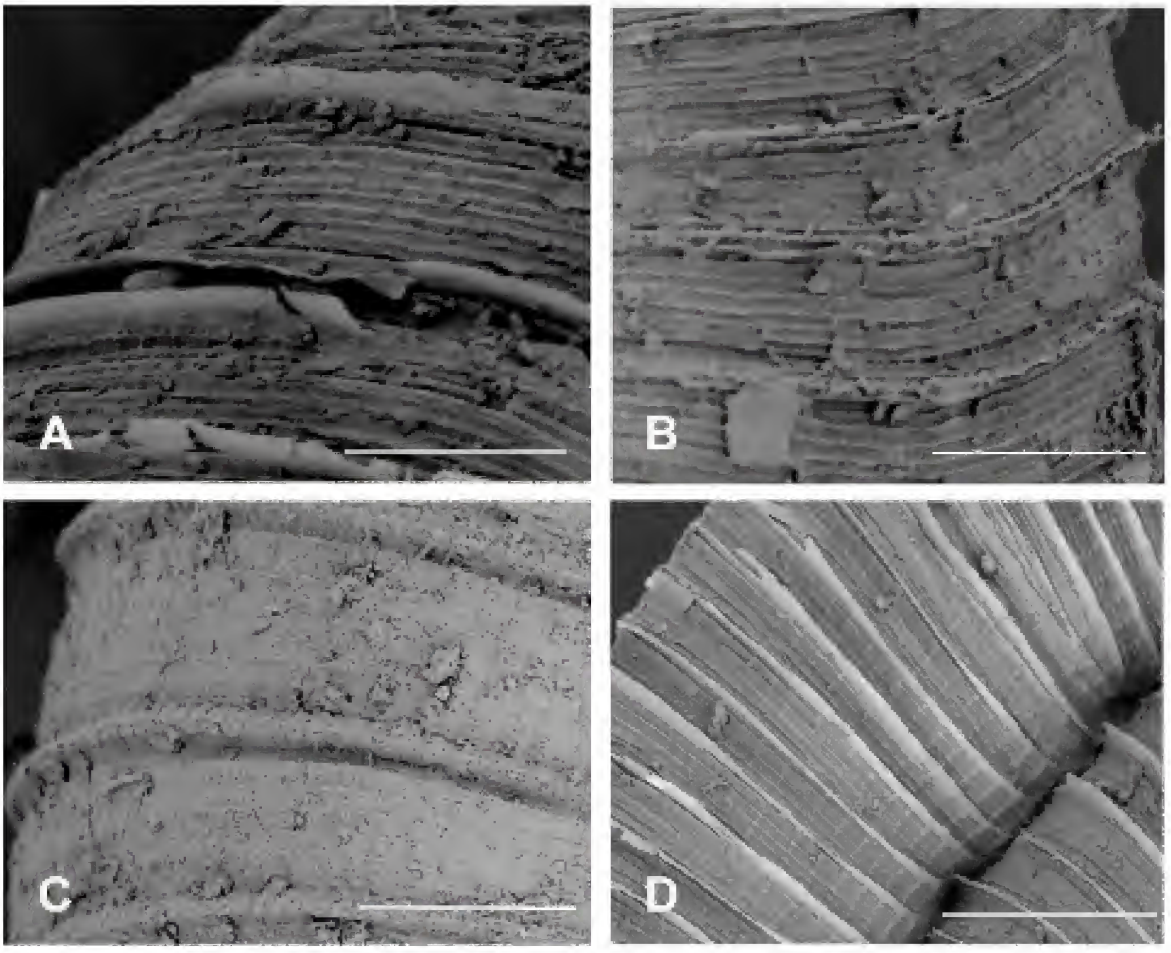


FIG. 7. Teleoconch sculpture of *Pereduropa* species. **A,** *P. cursacosta*, QMMO11901, Cape Hillsborough, MEQ; **B,** *P. delicata,* AMSC154896, Mt Dryander, MEQ; **C,** *P. hamiltoniana,* QMMO86089, Hamilton I., MEQ; **D,** *P. burwelli* sp. nov., QMMO6374, Broken R., MEQ. Scale bars = 100 µm. Magnification x800.

Pereduropa species have protoconchs with 17-19 (mean 18) spiral cords with a radial rib distance of 8 to 15 µm at the end of the first whorl and a distance between the spiral cords and radial ribs. This closer, more numerous ribbing at times forms a 'squarish' pattern on the first whorl, particularly if the specimen is worn. However, stronger spiral cords rise over the finer ribs in a scalloped pattern unlike those with the truly webbed pattern (Fig. 4). *Isolderopa* species also display a scalloped pattern with stronger spiral cords rise over rounded radial ribbing, but have smaller protoconch diameters than the species of the other two genera and only 12-20 spiral cords (mean 15) with a radial rib distance of 8 to 10 µm at the end of the first whorl (Fig. 5). The rounded protoconch ribbing appears less distinct than the finer ribbing of *Pereduropa* species. *Tristanoropa* species have a similar pattern with the first quarter of a whorl of spiral cords followed by a strongly scalloped pattern with 17-19 spiral cords (mean 18) and a radial rib distance of 10 μm (Fig. 6). The *Tristanoropa* scalloped pattern is

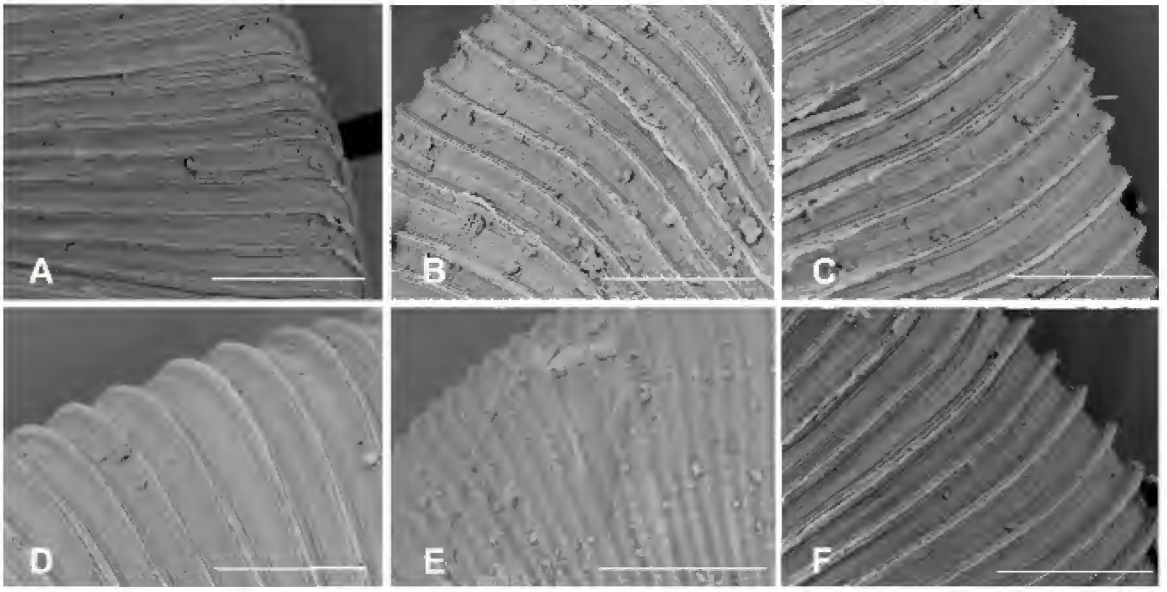


FIG. 8. Teleoconch sculpture of *Isolderopa* species. **A,** *I. iangallowayi*, QMMO85131, Mt Charlton, MEQ; **B,** *I. minuta*, QMMO78980, Eungella NP, MEQ; **C,** *I. deliqua*, QMMO78963, Calen-Mt Charlton Rd, MEQ; **D,** *I. teemburra* sp. nov., QMMO35809, Endeavour Ck, MEQ; **E,** *I. whitsunday* sp. nov., QMMO11902, Cape Hillsborough, MEQ; **F,** *I. diamante* sp. nov., QMMO77078, Diamond Cliffs, MEQ. Scale bars = 100 µm. Magnification x800.

composed of strong spiral cords and strong radial ribs that give a very definite rectangular pattern. While these patterns are similar, the three genera in question can be differentiated by major differences in shell coiling pattern, spire protrusion and the presence of apertural barriers.

Teleoconch sculpture of the twelve species exhibited bladed ribbing in eleven of the species and rounded ribbing in only one, *Pereduropa hamiltoniana* (Figs 7, 8 and 9). The microsculpture of the interstitial radial threads varied in number and size between species. Spiral cords were broad and buttressed against the microradial threads in all species. However, in *Isolderopa* species, the spiral cords were much less defined and appeared missing on the body whorl of *I. minuta*.

Apertural Barriers. Apertural barriers are not present in species of *Pereduropa* or *Tristanoropa*. However, barriers are present in many of the species of *Isolderopa*.

Isolderopa iangallowayi Stanisic, 2010 has an aperture with two vertical palatal barriers (Fig. 10A). *Isolderopa minuta* Stanisic, 2010 has two internal vertical barriers and one parietal barrier (Fig. 10B, C). *Isolderopa whitsunday* sp. nov. has five vertical palatal barriers but no parietal barriers (Fig. 10D). *Isolderopa deliqua* Stanisic, 2010 and *I. teemburra* sp.nov. have no known barriers.

SYSTEMATICS

Pereduropa Stanisic, 2010

Type species. *Pereduropa cursacosta* Stanisic, 2010-by original designation.

Diagnosis. Shell tiny, brown, discoidal with a flat to slightly elevated spire, whorls evenly coiled, sutures impressed; protoconch sculpture finely cancellate consisting of 17-19 scalloped, fine, crisp, crowded spiral cords over weaker radial ribs with a spacing averaging 8-15 m, teleoconch sculpture of crowded radial ribs,

microsculpture of microradial threads and low spiral cords; umbilicus wide V-shaped.

Remarks. *Pereduropa* has a finely cancellate protoconch sculpture similar to that of *Isolderopa* but can be distinguished from the latter genus by other aspects of shell morphology, in particular, the raised spire. *Pereduropa* can be distinguished from *Tristanoropa* gen. nov. by the nautiloid coiling pattern as compared with the multi-whorled pattern of the latter. *Pereduropa* differs from *Shearopa* which has species in SEQ and WT by the lack of apertural barriers.

Pereduropa cursacosta Stanisic, 2010
(Figs 4A, 7A, 11A, 15, Table 1)

Pereduropa cursacosta Stanisic, 2010 in Stanisic *et al.* 2010: 262.

Common Name. Coarse-ribbed Pinwheel Snail.

Materials examined. Holotype. QMMO13082, Bell's Gap, c.15 km S of Sarina, Sarina Range, 21° 31′ S, 149° 07′ E, nvf, coll. J Stanisic, 7.vii.1982.

Paratype. QMMO78972, 8RC, same data as holotype.

Other material. Cape Hillsborough NP: QMMO11901, 3RC; ; Hatfield's Gap: QMMO19993, 1RC; Mackay-Seaforth Rd: QMMO13473, 1RC; Mt Macartney: QMMO59649, 1RC; Nebo-Mackay Rd: QMMO85133, 5RC; Nth Mackay, Hicks Rd: QMMO85127, 4RC.

Diagnosis. Shell tiny, mean diameter 2.35 mm, with a slightly elevated spire, mean shell height 1.33 mm; protoconch finely cancellate with 17 scalloped spiral cords, mean radial rib spacing 10 µm, diameter 410 µm; teleoconch with 44 –72 (mean 55) radial ribs on first whorl; wide V-shaped umbilicus, mean D/U ratio 2.87.

Description. Shell tiny, brown, discoidal with a slightly elevated spire, whorls 4.0-4.5 evenly coiled, sutures impressed; diameter of shell 2.13-2.54 mm, height 1.23-1.48 mm, H/D 0.53-0.62 (mean 0.57). Protoconch flat, 1.5 whorls with a diameter of 410 µm sculptured with a scalloped finely cancellate pattern consisting of fine, crisp, crowded spiral cords and widely spaced, weak radial ribs; teleoconch sculpture of bladed, crowded radial ribs 44-60 on first whorl, microsculpture of microradial threads and low, broad spiral cords; umbilicus wide V-shaped, diameter 0.74-0.90 mm, D/U 2.70-

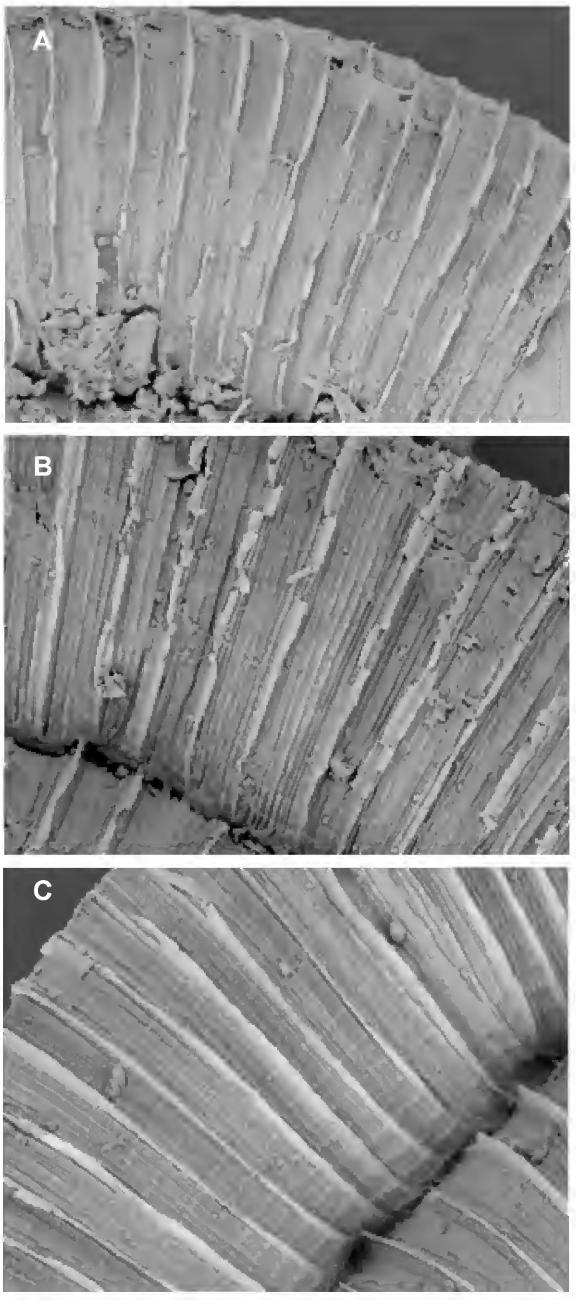


FIG. 9. Teleoconch sculpture of *Tristanoropa* gen. nov. species. **A,** *T. hughesae* sp. nov., QMMO50905, Eungella NP, MEQ; **B,** *T. conwayensis* sp. nov., AMSC154891, Brandy Creek, MEQ. Scale bars = 100 µm. Magnification x800.

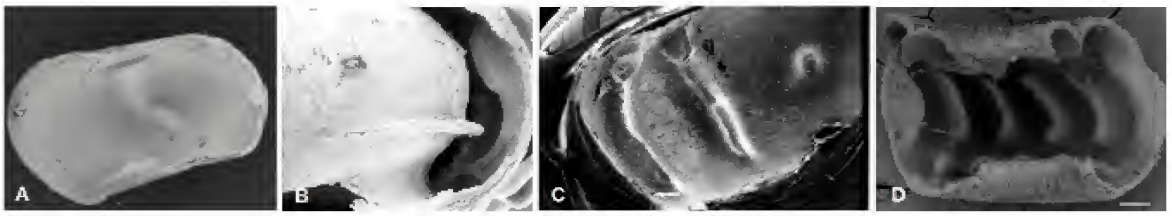


FIG. 10. Barriers in *Isolderopa* species. **A,** Palatal barriers in *I. iangallowayi*, QMMO78962, Mt Charlton, MEQ; **B,** Parietal barrier in *I. minuta*, QMMO9737, Broken R., MEQ; **C,** Palatal barriers in *I. minuta*, QMMO9726, Eungella NP, MEQ; **D,** Multiple palatal barriers of *I. whitsunday*, QMMO74081, Long I, MEQ. Images B, C: John Stanisic, QM.

3.30 (mean 2.89). Based on 8 measured adult specimens.

Distribution and habitat. Mackay-Sarina hinterland, MEQ, in rainforest and vine thicket; living under logs and other forest debris, in litter.

Remarks. *Pereduropa cursacosta* differs from *P. delicata* and *P. burwelli* sp. nov. in having coarser, more widely spaced ribs on the teleoconch. *Pereduropa cursacosta* differs from *P. hamiltoniana* by having bladed ribs on the teleoconch in contrast to the rounded ribs of the latter.

Pereduropa delicata Stanisic, 2010
(Figs 4B, 7B, 11B, 15, Table 1)

Pereduropa delicata Stanisic, 2010 in Stanisic *et al.* 2010: 262.

Common Name. Delicate-ribbed Pinwheel Snail.

Material examined. Holotype. QMMO13090, c.19 km N of Proserpine, beside Gregory R., 20°17′S, 148°35′E, nvf, coll. J. Stanisic, 6.vii.1982.

Paratypes. QMMO35547, 2RC, Mt Dryander, lower slopes, via Gregory, NE Proserpine, 20° 17′ S, 148° 35′ 30″ E, coll. J. Stanisic, D. Potter, N. Potter, 16.v.1990; QMMO78971, 7RC, ca. 19k N. of Proserpine, beside Gregory R., 20° 17′ S, 148° 35′ E, coll. J. Stanisic, 6.vii.1982.

Other material. Mt Dryander: QMMO31293, 1SC; AMSC154896, 9RC; QMMO35562, 1SC.

Diagnosis. Shell tiny, mean diameter 2.01 mm, with flat to a slightly elevated spire, mean shell height 1.11 mm; protoconch finely cancellate with 19 scalloped spiral cords, mean radial rib spacing 15 µm, diameter 410 µm; teleoconch with 62–91 (mean 75) radial ribs on first whorl; umbilicus wide V-shaped, mean D/U ratio 2.76.

Description. Shell tiny, brown, discoidal with a flat to slightly raised spire, whorls 4.0–4.875 evenly coiled, sutures impressed; diameter of shell 1.72–2.21 mm (mean 2.01 mm), height 0.98–1.23 mm (mean 1.1 mm), H/D 0.48–0.58 (mean 0.55). Protoconch flat, 1.5–1.625 whorls with a diameter of 410 µm sculptured with a scalloped finely cancellate pattern consisting of fine, crisp, crowded spiral cords and widely spaced, rounded radial ribs; teleoconch sculpture of bladed, crowded radial ribs 62–82 (mean 73) on first whorl, microsculpture of microradial threads and low, broad spiral cords; umbilicus wide V-shaped, diameter 0.57–0.90 mm (mean 0.75 mm), D/U 2.27–3.57 (mean 2.73). Based on 7 measured adult specimens.

Distribution and habitat. Mackay-Proserpine, MEQ; rainforest living in litter.

Remarks. *Pereduropa delicata* is distinguished from *P. cursacosta* and *P. hamiltoniana* by having a higher mean value of ribs on the teleoconch than the latter two but differs from *P. burwelli* sp. nov. by having less ribs on the teleoconch. The mean protoconch diameter of *P. delicata* (410 µm) differs from that of *P. burwelli* (490 µm) and *I. diamante* (330 µm).

Pereduropa hamiltoniana Stanisic, 2010
(Figs 4C, 7C, 11C, 15, Table 1)

Pereduropa hamiltoniana Stanisic, 2010, in Stanisic *et al.* 2010: 262.

Common Name. Hamilton Island Pinwheel Snail.

Materials examined. Holotype. QMMO65834, Hamilton I., c.2.5 km N of main resort on E side, Whitsunday Group, 20°20′23″S, 148°57′24″E, *Araucaria*/vine thicket, coll. J. Stanisic, J. Chaseling, 26.vi.1999.

Paratypes. QMMO60585, 1RC, Whitsunday Group, Whitsunday I, 20° 18′ S, 149° 3′ 30″ E, coll. J. Stanisic, 2.x.1996; QMMO78970, 6RC, same data as holotype.

Other material. Hamilton I.: QMMO86089, 2RC. Gloucester I.: QMMO74109, 1RC.

Diagnosis. Shell tiny, mean diameter 1.9 mm, with a flat to slightly raised slightly elevated spire, mean shell height 1.33 mm; protoconch finely cancellate with 19 scalloped spiral cords and radial ribs 15 µm apart, diameter 410 µm; teleoconch with mean 43 radial ribs on first whorl and more widely spaced teleoconch on the body whorl; umbilicus wide V-shaped, mean D/U ratio 2.97.

Description. Shell minute, orange-brown, discoidal with a flat to slightly raised spire, whorls 4.25–4.375 evenly coiled, sutures impressed; diameter of shell 1.8– 2.05 mm (mean 1.9 mm), height 0.98–1.08 mm (mean 1.08 mm); H/D 0.52–0.61 (mean 0.57). Protoconch flat, 1.50–1.625 whorls with a diameter 410 µm sculptured with a scalloped finely cancellate pattern consisting of fine, crisp, crowded spiral cords and widely spaced, weak radial ribs; teleoconch sculpture of rounded, crowded radial ribs 42–45 (mean 43) on first whorl, microsculpture of microradial threads and low spiral cords; umbilicus wide V-shaped, diameter 0.57–0.74 mm (mean 0.64 mm). D/U 2.78–3.29 (mean 2.97). Based on 6 measured adult specimens.

Distribution and habitat. Whitsunday islands, MEQ; rainforest and vine thicket living in litter.

Remarks. *Pereduropa hamiltoniana* is distinguished from *P. cursacosta* and *P. delicata* by having a more elevated spire and more widely spaced ribs on the teleoconch. *P. hamiltoniana* differs from other *Pereduropa* species by having rounded, as opposed to bladed, ribs on the teleoconch and a smaller aperture width. The drier coastal rainforests of the off-lying islands of MEQ, which receive an annual average rainfall of 1 600 mm (Bureau of Meteorology 2017), support this species which has not yet been found on the mainland.

Pereduropa burwelli sp. nov.
(Figs 4D, 7D, 11D, 15, Table 1)

Etymology. Named for Queensland Museum entomologist Dr Chris Burwell.

Preferred common name. Burwell's Pinwheel Snail.

Materials examined. Holotype. QMMO6372, Eungella NP, Dalrymple Heights, 21° 2′S, 148° 36′E, coll. M. Bishop, xi.1976. Diameter 2.21 mm, height 1.31 mm, H/D 0.59, D/U 4.5, number of whorls 4.375.

Paratype. QMMO6369, 10RC, same data as holotype.

Other material. Eungella NP: QMMO85071, 1 RC; QMMO85103, 1 RC; QMMO85105, 1 RC; QMMO6374, 1RC; QMMO86550, 12RC; QMMO11759, 1RC; QMMO42392, 1RC; QMMO85084, 1RC; QMMO85170, 1RC; QMMO85171, 1RC. Dalrymple Heights: AMSC154899, 1RC. Mt William: AMSC154908, 1RC. Crediton Creek: QMMO6355, 3RC; QMMO85177, 8RC; QMMO13075, 5RC. Finch Hatton NP: QMMO6365, 1RC; QMMO85075, 1RC; AMSC151906, 1RC.

Diagnosis. Shell tiny, mean diameter 2.21 mm with a flat to slightly elevated spire, mean shell height 1.24 mm; protoconch finely cancellate with 18 scalloped spiral cords, mean radial rib spacing 15 µm, protoconch diameter 490 µm; teleoconch with mean 93 radial ribs on first whorl; umbilicus wide V-shaped, D/U 3.37.

Description. Shell tiny, brown, discoidal with a flat to slightly raised spire, whorls 4.0–4.375 evenly coiled, sutures impressed; diameter of shell 2.05–2.54 mm (mean 2.21 mm), height 1.15–1.48 mm (mean 1.24 mm), H/D 0.50–0.62 (mean 0.56). Protoconch flat, 1.50–1.875 whorls with a diameter of 490 µm sculptured with a scalloped finely cancellate pattern consisting of fine, crisp, crowded spiral cords and widely spaced, weak radial ribs; teleoconch sculpture of bladed, very crowded radial ribs 78–116 (mean 101) on first whorl, microsculpture of microradial threads and low spiral cords; umbilicus wide V-shaped, diameter 0.49–0.74 mm (mean 0.66 mm), D/U 2.89–4.50 (mean 3.37). Based on 15 measured adult specimens.

Distribution and habitat. Eungella NP, MEQ; rainforest and vine thicket living in litter.

Remarks. *Pereduropa burwelli* now named is distinguished from its congeners by having a larger protoconch diameter, more finely spaced

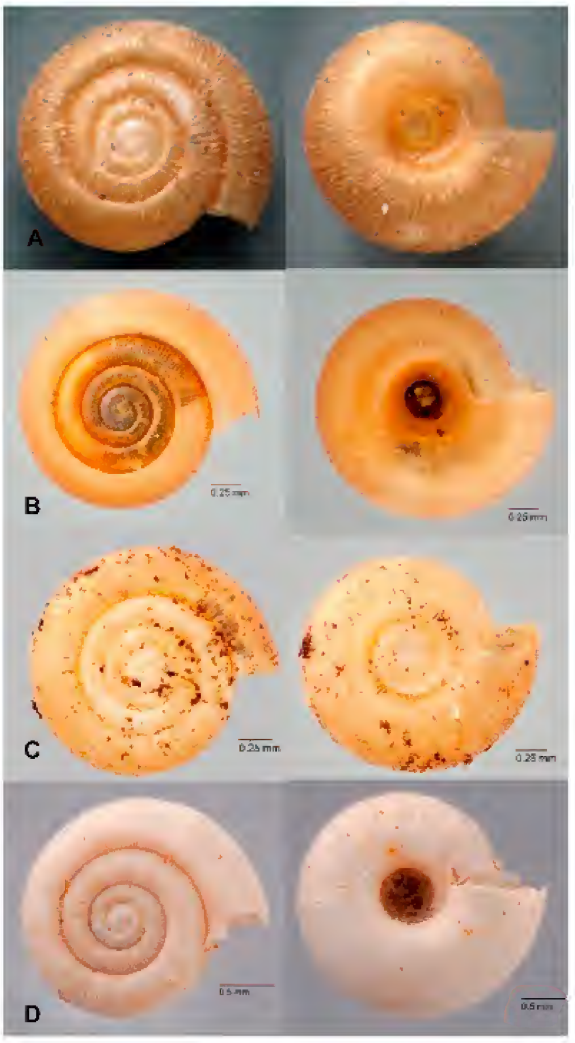


FIG. 11. Dorsal and ventral views of holotypes of *Pereduropa* species. **A,** *P. cursacosta*, QMMO13082, Bell's Gap, MEQ; **B,** *P. delicata*, QMMO13090, N of Proserpine, MEQ; **C,** *P. hamiltoniana*, QMMO65834, Hamilton I, MEQ; **D,** *P. burwelli* sp. nov., QMMO6732, Dalrymple Hts, MEQ. Images A: John Stanisic; B-D: Geoff Thompson, QM.

ribs on the teleoconch and a much larger D/U ratio (Table 1). *Pereduropa burwelli* is one of the larger *Pereduropa* species and appears to be restricted to the moist rainforests of Eungella NP in the Clarke Range. With an annual rainfall of around 2300 mm (Bureau of Meteorology 2017), the Eungella plateau rises to an altitude of 1259 m at Mt Dalrymple. *Pereduropa burwelli* is not known at altitudes below the upper reaches of Crediton Ck and Finch Hatton Gorge (606 m) and is distinguished from *P. cursacosta* which has been found at lower altitudes by much finer ribbing on the teleoconch.

Isolderopa Stanisic, 2010

Type species. *Isolderopa iangallowayi* Stanisic, 2010-by original designation.

Diagnosis. Shell tiny, brown, biconcave with a depressed to very depressed spire, whorls tightly coiled; protoconch sculpture finely cancellate consisting of 12 – 17 scalloped, fine, crisp, crowded spiral cords and widely spaced, strong radial ribs with a spacing averaging 10 µm; teleoconch sculpture of densely crowded radial ribs, microsculpture of microradial threads and low spiral cords; aperture usually with barriers, palatal barriers when present, vertical; umbilicus wide V-shaped to wide cup-shaped.

Remarks. The combination of a strongly sunken spire with more prominent apical spiral cords and vertical palatal barriers distinguishes *Isolderopa* from *Shearopa*, *Tristanoropa* gen. nov. and *Pereduropa*. Furthermore, *Isolderopa* is also distinguished from *Tristanoropa* gen. nov. by its nautiloid coiling pattern compared with the multi-whorled pattern of the latter.

Isolderopa iangallowayi Stanisic, 2010
(Figs 5A, 8A, 12A, 16, Table 1)

Isolderopa iangallowayi Stanisic, 2010 in Stanisic *et al.* 2010: 260.

Common name. Galloway's Pinwheel Snail.

Materials examined. Holotype. QMMO13102, c.17.5 km SW of Calen, on Calen Mt Charlton Road, 21°00′ S, 148°42′ E, nvf, coll. J Stanisic, 6.vii.1982.

Paratypes. QMMO50880, 8RC, Eungella NP, Rocky Ck, 20° 54′S, 148° 36′E, coll. ANZES, 29.xii.1993; QMMO78962, 17RC, same data as holotype.

Other material. Eungella NP: QMMO50885, 7RC; QMMO59641, 1RC; QMMO85116, 1SC; QMMO50891, 1RC; QMMO85076, 1 RC; QMMO85345, 3SC; QMMO86088, 2RC; Mt Charlton: QMMO85131, 11RC; Mt Dalrymple: QMMO36094, SC6; Mt Macartney: QMMO35633, SC7; QMMO35634, SC1; Mt Vince: AMSC140446, 3RC; Pelion SF: QMMO85082, 1 RC.

Diagnosis. Shell tiny, golden-brown, mean diameter 1.86 mm, biconcave with a deeply depressed spire, mean shell height 0.82 mm, very tightly coiled and laterally compressed; protoconch finely cancellate with 13–16 scalloped spiral cords, mean radial rib spacing 10 µm, protoconch diameter 330 µm; teleoconch with mean 104 radial ribs on the first whorl; aperture with 2 vertical internal palatal barriers; umbilicus deep V-shaped, mean D/U ratio 2.68.

Description. Shell tiny, golden-brown, biconcave with a very deeply sunken spire, whorls 4.875–5.375 very tightly coiled and laterally compressed, sutures impressed; diameter of shell 1.56–2.13 mm (mean 1.86 mm), height 1.07–1.23 mm (mean 1.16 mm); H/D 0.58–0.74 (mean 0.62). Protoconch flat, 1.50–1.75 whorls with a diameter of 330 µm sculptured with a scalloped finely cancellate pattern consisting of fine, crisp, crowded spiral cords and widely spaced, strong radial ribs; teleoconch sculpture of bladed, crowded radial ribs 88–120 (mean 104) on first whorl, microsculpture of microradial threads and low spiral cords; aperture with 2 internal vertical palatal barriers; umbilicus wide, deep V-shaped, diameter 0.66–0.74 mm (mean 0.7 mm). D/U 2.44–3.0 (mean 2.68). Based on 14 measured adult specimens.

Distribution and habitat. Eungella NP and Mt Charlton, MEQ; rainforest living in litter.

Remarks. *Isolderopa iangallowayi* is distinguished from *Pereduropa* species and *Tristanoropa* species by the combination of a very deeply sunken spire, very tightly coiled whorls and V-shaped umbilicus. The two vertical palatal barriers and more numerous whorls separates *I. iangallowayi* from other *Isolderopa* species.

Isolderopa minuta Stanisic 2010
(Figs 5B, 8B, 12B, 16, Table 1)

Isolderopa minuta Stanisic, 2010 in Stanisic *et al.* 2010: 260.

Common name. Golden Goblet Pinwheel Snail.

Materials examined. Holotype. QMMO13445, Broken R, Eungella NP, 21°10′ S, 148°30′ E, nvf, coll. J. Stanisic, 5.vii.1982.

Paratypes. QMMO9368, 12RC, Eungella NP, Dalrymple Heights, 21° 2′ S, 148° 36′ E, 1000 m, coll. M. Bishop, xi.1976; QMMO9726, 10RC, Crediton Ck, Eungella NP, 21°11′ S, 148° 32′ E, 850 m, coll. M. Bishop, xi.1976; QMMO9737, 6RC, Eungella NP, Broken R, 21°10′ S, 148°30′ E, 800m, coll. M. Bishop, xi.1976; QMMO13072, 4RC, Diggings Rd, Eungella NP, 21° 9′ S, 148° 29′ E, coll. J. Stanisic, 8.vii.1982; QMMO50886, 7 RC, Eungella NP, Rocky Ck, 20° 54′ S, 148°36′ E, coll. ANZES, 29.xii.1993; QMMO50904, 4RC, Eungella NP, 20°52′ S, 148°37′ E, coll. ANZES, 28.xii.1993; QMMO78980, 5RC, same data as holotype.

Other material. Bells Gap: QMMO13083, 2RC; Calen - Mt Charlton Rd: QMMO13100, 4RC; Crediton Ck: QMMO59543, 1SC, AMSC154907, 4RC; Eungella NP off Eungella Dam Rd: QMMO85114, 1SC; Eungella NP, Broken River: QMMO59643, 3 RC; Eungella NP, Entrance/lookout: QMMO85137, 5RC; Eungella NP, Finch Hatton Gorge: QMMO85066, 2RC; QMMO85072, 1RC; QMMO85085, 3RC; QMMO85087, 1RC; QMMO85099, 2RC; Eungella NP, Mt Dalrymple: QMMO50879, 1RC; QMMO85077, 1RC; QMMO85078, 10RC, QMMO85081, 3RC; QMMO85088, 1 RC; QMMO85093, 1RC; QMMO85094, 1 RC; QMMO85097, 2RC; QMMO85100, 1RC; Eungella NP, Mt Henry: QMMO85068, 1RC; QMMO85106, 2RC; Eungella NP, Mt William: QMMO85070, 1RC; AMSC154905, 2RC.

Diagnosis. Shell minute, brown, mean diameter 1.41 mm, biconcave with a deeply depressed spire, mean shell height 0.82 mm, tightly coiled laterally compressed; protoconch finely cancellate with 12–16 scalloped spiral cords, mean radial rib spacing 10 µm, protoconch diameter 250 µm; teleoconch with mean 124 crowded, radial ribs on first whorl; aperture with several internal vertical, palatal barriers and one parietal barrier; umbilicus wide saucer-shaped, mean D/U 2.18.

Description. Shell minute, brown, biconcave with a very deeply sunken spire, whorls 4.25–4.75 very tightly coiled and laterally compressed, sutures impressed; diameter of shell 1.23–1.64 mm (mean 1.41 mm), height 0.74–0.90 mm (mean 0.82 mm), H/D 0.53–0.63 (mean 0.58). Protoconch flat, 1.5–1.75 whorls with a diameter of 250 µm sculptured with a scalloped finely cancellate pattern consisting of fine, crisp, crowded spiral cords and widely spaced, strong radial ribs; teleoconch sculpture of bladed, crowded radial ribs 112–129 (mean 124) on first whorl, microsculpture of microradial threads and low spiral cords; aperture with several internal, vertical palatal barriers and one parietal lamella; umbilicus wide saucer-shaped; diameter 0.57–

0.74 mm (mean 0.65 mm), D/U 2.00–2.29 (mean 2.18). Based on 10 measured adult specimens.

Distribution and habitat. Eungella environs and the Clarke Ra., MEQ; rainforest living in litter.

Remarks. *Isolderopa minuta* differs from all other *Isolderopa* species by its small shell diameter, a minute protoconch diameter of 250 µm and in having a parietal lamella as well as vertical palatal barriers. *Isolderopa minuta* differs from *I. iangallowayi* by having a less depressed spire and much wider umbilicus. The Eungella plateau, home to *I. minuta*, rises to an altitude of 1 259 m at Mt Dalrymple where the species has been collected at 1 234 m. The species has also been collected from lower altitudes at Broken River (alt. 800 m) and Finch Hatton Gorge (alt. 400 m).

Isolderopa deliqua Stanisic, 2010
(Figs 5C, 8C, 12C, 16, Table 1)

Isolderopa deliqua Stanisic, 2010 in Stanisic *et al.* 2010: 260.

Preferred common name. Calen Pinwheel Snail formerly known as the Whitsunday Pinwheel Snail.

Materials examined. Holotype. QMMO13101, c.17.5 km SW Calen, on Calen-Mt Charlton Rd, 21°00′ S, 148°42′ E, nvf, coll. J. Stanisic, 6.vii.1982.

Paratypes. QMMO9725, 13RC, Eungella NP, Broken R, 21° 10′ S, 148° 30′ E, 800 m, coll. M. Bishop, xi.1976; QMMO13452, 19RC, Eungella NP, Broken R, 21° 10′ S, 148° 30′ E, coll. J. Stanisic, 5.vii.1982; QMMO78963, 5RC, same data as holotype; QMMO6354, 20RC, Crediton Ck, Eungella NP, 21° 11′ S, 148° 32′ E, coll. M. Bishop, xi.1976; QMMO78960, 4RC, Eungella NP, Broken R, 21° 10′ S, 148° 30′ E, coll. J. Stanisic, 5.vii.1982.

Other material. Crediton Ck: QMMO59544, 3SC. Eungella NP: QMMO50909, 1RC; QMMO6378, 1SC. Mt Charlton: QMMO85132, 1RC.

Diagnosis. Shell tiny, brown, mean diameter 1.95 mm, biconcave with a depressed spire, mean shell height 1.95 mm, very tightly coiled with a shallow sulcus on the upper half of body whorl of adults; protoconch finely cancellate with 17 – 19 scalloped spiral cords, mean radial rib spacing 10 µm, protoconch diameter 330 µm; teleoconch with mean 100 radial ribs on first whorl; umbilicus wide V-shaped, mean D/U ratio 2.43.

Description. Shell tiny, brown, biconcave with a depressed spire, whorls 4.125–4.75 tightly coiled with a shallow sulcus on upper half of body whorl in adults, sutures impressed; diameter of shell 1.64–2.21 mm (mean 1.95 mm), height 0.90–1.15 mm (mean 1.1 mm); H/D 0.52–0.68 (mean 0.57). Protoconch flat, 1.50–1.75 whorls with a diameter of 330 µm sculptured with a scalloped finely cancellate pattern consisting of fine, crisp, crowded spiral cords and widely spaced, strong radial ribs; teleoconch sculpture of bladed, densely crowded radial ribs 87–115 on first whorl, microsculpture of microradial threads and low spiral cords; aperture with no barriers; umbilicus saucer-shaped; diameter 0.74–0.82 mm (mean 0.80 mm). D/U 2.00–2.78 (mean 2.43). Based on 11 measured adult specimens.

Distribution and habitat. Eungella NP and Mt Charlton area, MEQ; rainforest and vine thicket living in litter.

Remarks. *Isolderopa deliqua* is distinguished from *I. iangallowayi*, *I. minuta*, and *I. whitsunday* sp. nov. by its lack of apertural barriers. *Isolderopa deliqua* differs from *I. teemburra* sp. nov. and *I. diamante* sp. nov. in having fewer ribs on the teleoconch and a higher D/U ratio. *Isolderopa teemburra* sp. nov. and *I. diamante* sp. nov. are endemic to a small area of the Endeavour Creek in Crediton SF and the Diamond Cliffs in Homevale NP, respectively, whereas *I. deliqua* is found across the rainforests of the higher altitudes of the Eungella plateau above 800 m and the Mt Charlton area. Stanisic *et al.* (2010) placed this species in *Isolderopa* with reservations. However, detailed morphological examination confirms this species as a member of the genus.

Isolderopa teemburra sp. nov.
(Figs 5D, 8D, 12D, 16, Table 1)

Etymology. Named for Teemburra Creek which is the major creek into which Endeavour Creek, the type locality, flows.

Preferred common name. Teemburra Pinwheel Snail.

Materials examined. QMMO35809, Endeavour Ck, Upper Reaches, Clarke Ra, W of Mackay, 21° 15′ 30″S, 148° 37′ 30″E, coll. J. Stanisic, D. Potter, N.

Potter, 20.v.1990. Diameter 2.05 mm, height 1.23 mm, H/D 0.60, D/U 2.27, number of whorls 4.375.

Paratypes. QMMO86547, 5SC/15RC, same data as holotype.

Other material. Cherry Tree Creek: QMMO85339, 1SC.

Diagnosis. Shell tiny, brown, mean diameter 1.97 mm, biconcave with a depressed spire, mean shell height 1.12 mm, tightly coiled laterally compressed; protoconch finely cancellate with 15–16 scalloped spiral cords, mean radial rib spacing 10 µm, protoconch diameter 330 µm; teleoconch with mean 119 very crowded, radial ribs on first whorl; umbilicus saucer-shaped, mean D/U 2.12.

Description. Shell tiny, brown, biconcave with a depressed spire, whorls 4.375–4.50 very tightly coiled and laterally compressed, sutures impressed; diameter of shell 1.89–2.05 mm (mean 1.97 mm), height 1.07–1.23 mm (mean 1.12 mm), H/D 0.54–0.60 (mean 0.57). Protoconch flat, 1.625–1.75 whorls with a diameter of 330 µm sculptured with a scalloped finely cancellate pattern consisting of fine, crisp, crowded spiral cords and widely spaced, rounded radial ribs; teleoconch sculpture of bladed, very densely crowded radial ribs 110–125 (mean 119) on first whorl, microsculpture of microradial threads and low spiral cords; aperture with no barriers; umbilicus wide, saucer-shaped, diameter 0.90–0.98 mm (mean 0.93 mm), D/U 2.00–2.27 (mean 2.12). Based on 3 measured adult specimens.

Distribution and habitat. Endeavour Creek and Cherry Tree Creek, both tributaries of Teemburra Creek in Crediton SF and Finch Hatton Gorge, MEQ; rainforest living in litter.

Remarks. *Isolderopa teemburra* is distinguished from most other *Isolderopa* species, with the exception of *I. deliqua* and *I. diamante* sp. nov., by having no apertural barriers. *Isolderopa teemburra* can be distinguished from *I. deliqua* by having finer teleoconch ribbing, 4–5 microradial ribs versus 6–7 microradial ribs in the latter, a much wider umbilicus and lower D/U ratio. *Isolderopa teemburra* has been found at Finch Hatton Gorge at an altitude of 244 m, and Endeavour Creek and Cherry Tree Creek in the lower altitudes of Crediton State Forest, MEQ (alt. 575 m).

Isolderopa whitsunday sp. nov.
(Figs 5E, 8E, 12E, 16, Table 1)

Etymology. Named for the Whitsunday Bioprovince.

Preferred common name. Whitsunday Pinwheel Snail.

Materials examined. Holotype: QMMO13089, c. 19k N. of Proserpine, beside Gregory R., 20° 17'S, 148° 35'E, coll. J. Stanisic, 6.vii.1982. Diameter 1.56 mm, height 0.9 mm, H/D 0.58, D/U 2.38, number of whorls 4.5.

Paratype. QMMO86548, 12RC, same data as holotype.

Other material. Brandy Ck SF: QMMO86565, 1RC; AMSC154890, 22RC. Cape Hillsborough NP: QMMO11902, 11RC; QMMO59642, 1RC. c.45 km N Mackay. Hamilton I: QMMO65835, 1RC; QMMO86073, 2RC. Long I: QMMO74081, 2RC. Mt Dryander: QMMO35548, 4RC; AMSC154892, 1RC; AMSC154895, 10RC; QMMO60586, 4RC. Mackay-Seaforth Road: QMMO13474, 1RC. Conway Range NP: QMMO85125, 1RC; QMMO85333, 1SC. Jaxut SF: QMMO85128, 15RC; Proserpine: QMMO68647, 16RC. West Molle I.: QMMO6348; QMMO86549, 5RC.

Diagnosis. Shell tiny, golden-brown, mean diameter 1.66 mm, biconcave with a depressed spire, mean shell height 0.86 mm, tightly coiled, laterally compressed; protoconch finely cancellate with 12–16 scalloped spiral cords, mean radial rib spacing 10 µm, protoconch diameter 330 µm; teleoconch with mean 118 crowded, radial ribs on first whorl; mean aperture height 0.74 mm; aperture with five internal vertical, palatal barriers; umbilicus wide saucer-shaped, mean D/U 2.40.

Description. Shell tiny, golden-brown, biconcave with a depressed spire, whorls 4.125–5.0 tightly coiled with a shallow sulcus on upper half of body whorl in adults, sutures impressed; diameter of shell 1.48–2.05 mm (mean 1.66 mm), height 0.82–0.90 mm (mean 0.86 mm), H/D 0.44–0.58 (mean 0.52). Protoconch flat, 1.50–1.625 whorls with a diameter of 330 µm sculptured with a scalloped finely cancellate pattern consisting of fine, crisp, crowded spiral cords and widely spaced, strong radial ribs; teleoconch sculpture of bladed, very densely crowded radial ribs 108–130 (mean 118) on first whorl, microsculpture of microradial threads and low spiral cords; aperture with five vertical palatal barriers; umbilicus wide, saucer-shaped; diameter 0.66–0.74 mm (mean

0.70 mm), D/U 2.09–2.75 (mean 2.40). Based on 18 measured adult specimens.

Distribution and habitat. Mackay-Proserpine area, Cape Hillsborough and off lying Whitsunday islands, MEQ; rainforest and vine thicket living in litter.

Remarks. *Isolderopa whitsunday* sp. nov. is distinguished from other *Isolderopa* species by having five vertical palatal barriers and no parietal barriers. *Isolderopa whitsunday* has very crowded teleoconch ribbing similar to that in *I. minuta* but differs from that species in its larger shell diameter, larger protoconch width and higher mean D/U ratio.

Isolderopa diamante sp. nov.
(Figs 5F, 8F, 12F, 16, Table 1)

Etymology. From the French diamant = diamond, referring to the type locality.

Preferred common name. Diamond Cliffs Pinwheel Snail.

Material examined. Holotype. QMMO86546, Mackay, WSW at Diamond Cliffs, Homevale NP, 21° 22′ 59″S, 148° 34′ 21″E, coll. QM party, 14.x.2005. Diameter 1.56 mm, height 0.90 mm, H/D 0.58, D/U 2.38, number of whorls 4.

Paratypes. QMMO77078, 100RC, same data as holotype.

Diagnosis. Shell tiny, mean diameter 1.55 mm with a depressed spire, mean shell height 0.93 mm; protoconch finely cancellate with 18 scalloped spiral cords, mean radial rib spacing 8 µm, protoconch diameter 330 µm; teleoconch with mean 108 radial ribs on first whorl; umbilicus wide V-shaped, mean D/U 2.32.

Description. Shell tiny, pale brown, discoidal with a depressed spire, whorls 3.75–4.25 evenly coiled, sutures impressed; diameter of shell 1.39–1.62 mm (mean 1.55 mm), height 0.82–1.15 mm (mean 0.93 mm), H/D 0.56–0.67 (mean 0.6). Protoconch flat, 1.50–1.75 whorls with a diameter of 330 µm sculptured with a scalloped finely cancellate pattern consisting of fine, crisp, crowded spiral cords and widely spaced, weak radial ribs; teleoconch sculpture of bladed, very crowded radial ribs 102–117 (mean 108) on first whorl, microsculpture of microradial threads and low, broad spiral cords; umbilicus wide V-shaped, diameter 0.57–0.74 mm (mean 0.67 mm), D/U 2.10–2.43 (mean 2.32). Based on 7 measured adult specimens.

Distribution and habitat. Homevale NP, MEQ; rainforest living in litter.

Remarks. *Isolderopa diamante* sp. nov. is distinguished from its congeners (excluding *I. minuta*) by having a smaller shell diameter. *Isolderopa diamante* can be separated from *I. minuta* by having a larger protoconch diameter and D/U ratio and a smaller H/D ratio. Unlike other *Isolderopa* species which have more widely ranging distributions. *Isolderopa diamante* appears to be endemic to a small area of dry rainforest in the Diamond Cliffs, MEQ. Thirty million years ago a series of eruptions covered older basalt rocks with lava, creating hard granite formations. Over time, basalt eroded away more easily leaving the Diamond Cliffs on the eastern escarpment of Mt Britton. No other species of *Isolderopa* is hitherto known from this area.

Tristanoropa gen. nov.

Type species. *Tristanoropa hughesae* sp. nov.

Etymology. From the tale of 'Tristan and Isolde' inspired by Celtic legend and the relationship to *Isolderopa* and a contraction of Charopa.

Diagnosis. Shell tiny, brown, discoidal, multi-whorled with a flat spire, whorls numerous (>4.5) and tightly coiled; sutures impressed; protoconch finely cancellate with 17–19 scalloped spiral cords, mean radial rib spacing 10 µm, protoconch length 1.50–1.625 whorls; teleoconch bladed with crowded radial ribs, microsculpture of prominent microradial threads and numerous, well-defined microspiral cords lifting over the microradial ribs; umbilicus V-shaped.

Remarks. *Tristanoropa* gen. nov. is distinguished from other MEQ genera with a finely cancellate protoconch by the combination of multi-whorled coiling pattern and flat spire. *Tristanoropa* is similar to *Shearopa* from SEQ and WT, in shell sculpture and coiling pattern but lacks the lamellate barriers of the latter. The umbilicus also differs between the two genera, being V-shaped in

Tristanoropa species and wide cup-shaped in *Shearopa* species.

Tristanoropa hughesae sp. nov.
(Figs 6A, 9A, 13A, 17, Table 1)

Etymology. Named for Professor Jane Hughes from Griffith University.

Preferred common name. Hughes' Pinwheel Snail.

Materials examined. Holotype. QMMO85130, Mt Charlton, Calen-Mirani Rd, rainforest, 21°00'S, 148°42'E, litter, 129 m, coll. G. Annabell, 18.iv.1984. Diameter 2.21 mm, height 1.31 mm, H/D 0.59, D/U 4.5, number of whorls 4.375.

Paratypes. QMMO85136, 7RC, Mt Charlton, 2 miles N, Calen-Mirani Rd, rainforest, 21°01'S, 148°03'E, litter, coll. G. Annabell, 11.iv.1982.

Other Material. Calen - Mt Charlton Rd: QMMO13099, 10RC. Eungella NP: QMMO50881, 3RC; QMMO59542, 1SC; QMMO50887, 8RC; QMMO50892, 1RC; QMMO50897, 2RC; QMMO50905, 2RC; QMMO51000, 2RC. Mt Dalrymple: QMMO36095, 2SC

Diagnosis. Shell tiny, brown, mean diameter 1.66 mm, multi-whorled with a flat spire, mean shell height 0.94 mm, tightly coiled laterally compressed; protoconch finely cancellate with mean 18 scalloped spiral cords, mean radial rib spacing 10 µm, protoconch diameter 410 µm, mean 1.52 whorls; teleoconch with mean 109 crowded, radial ribs on first whorl; umbilicus V-shaped, mean D/U 2.59.

Description. Shell tiny, brown, discoidal with a flat spire, whorls 4.50–5.00 multi-whorled, sutures impressed; diameter of shell 1.39–1.89 mm (mean 1.66 mm), height 0.82–1.07 mm (mean 0.94 mm), H/D 0.48–0.62 (mean 0.57). Protoconch flat, 1.50–1.625 whorls with a diameter of 410 µm sculptured with a scalloped finely cancellate pattern consisting of fine, crisp, crowded spiral cords and widely spaced, strong radial ribs; teleoconch sculpture of bladed, very crowded radial ribs 104–112 (mean 109) on the first whorl, microsculpture of microradial threads and low, broad spiral cords; umbilicus wide V-shaped, diameter 0.57–0.74 mm (mean 0.64 mm), D/U 2.38–3.00 (mean 2.59). Based on 7 measured adult specimens.

Distribution and habitat. Eungella NP and Mt Charlton, MEQ; rainforest and vine thicket living in litter.

Remarks. *Tristanoropa hughesae* is distinguished from its congener by having a greater number of whorls, a larger protoconch diameter and more finely spaced ribs on the teleoconch. *Tristanoropa hughesae* can also be differentiated from *T. conwayensis* sp. nov. by its shorter mean protoconch length of 1.52 whorls. A close examination of the finely cancellate protoconch patterns show that of *T. hughesae* (mean 18 spiral cords) is similar to that of *T. conwayensis,* (mean 19 spiral cords) with both revealing a strongly 'rectangular' pattern.

Tristanoropa conwayensis sp. nov.
(Figs 6B, 9B, 13B, 17, Table 1)

Etymology. Named for the Conway Range, MEQ, which includes the type locality of Brandy Creek SF.

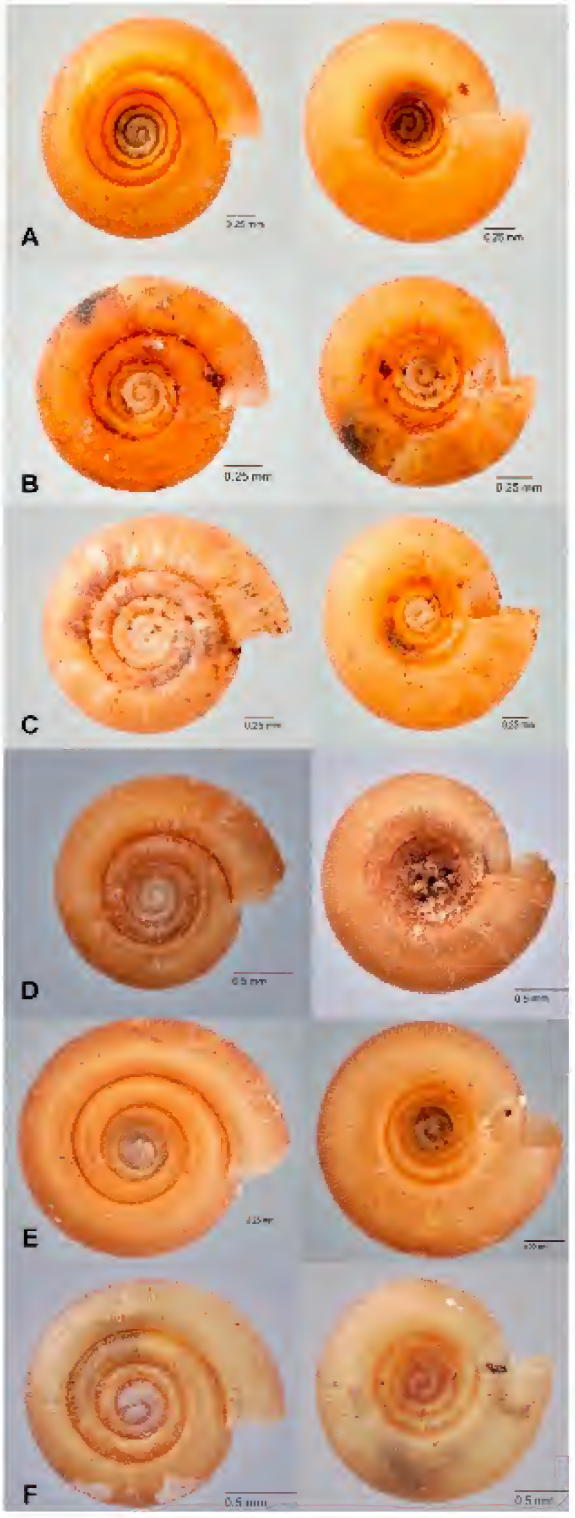
Preferred common name. Brandy Creek Pinwheel Snail.

Materials examined. Holotype. AMSC154891, Brandy Ck SF, E of Proserpine, MEQ, 20° 21'S, 148° 43'E, 120 m, cnvf, litter, coll. J. Burch, W. Ponder, 2.v.1975. Diameter 1.72 mm, height 0.98 mm, H/D 0.57, D/U 2.63, number of whorls 4.675.

Paratypes. AMSC560994, same data as holotype; QMMO85336, 3SC, Brandy Creek NP, MEQ, 20° 21'S, 148° 43'E, rainforest, litter, under logs, coll. J. Stanisic, L. Holcroft, 14.xi.2016.

Diagnosis. Shell tiny, brown, mean diameter 1.73 mm, multi-whorled with a flat spire, mean shell height 1.02 mm, tightly coiled laterally compressed; protoconch finely cancellate with mean 19 scalloped spiral cords, mean radial rib spacing 10 µm, protoconch diameter 330 µm, 1.6 whorls; teleoconch with mean 79 crowded, radial ribs on first whorl; umbilicus V-shaped, mean D/U ratio 2.62.

Description. Shell tiny, brown, discoidal with a flat spire, whorls 4.25–5.25 multi-whorled, sutures impressed; diameter of shell 1.64–1.89 mm (mean 1.73 mm), height 0.98–1.23 mm (mean 1.02 mm); H/D 0.52– 0.65 (mean 0.59). Protoconch flat, 1.50–1.625 (mean 1.53) whorls with a diameter of 330 µm sculptured with a scalloped finely cancellate pattern consisting



of fine, crisp, crowded spiral cords and widely spaced, weak radial ribs; teleoconch sculpture of bladed, crowded radial ribs 70–96 on first whorl, microsculpture of microradial threads and low, broad spiral cords; umbilicus wide V-shaped, diameter 0.57–0.74 mm (mean 0.67 mm). D/U 2.22–3.29 (mean 2.62). Based on 8 measured adult specimens.

Distribution and habitat. Brandy Creek SF, Conway Range, MEQ; rainforest living in litter.

Remarks. *Tristanoropa conwayensis* sp. nov. is distinguished from *T. hughesae* sp. nov. by having a smaller protoconch diameter, a larger H/D ratio and shell height and less ribs on the teleoconch. *Tristanoropa conwayensis* has a greater number of spiral cords on the protoconch (mean 19) than *T. hughesae* (mean 18) spiral cords. *Tristanoropa conwayensis* appears to be endemic to the rainforests of Brandy Creek NP, MEQ.

DISCUSSION

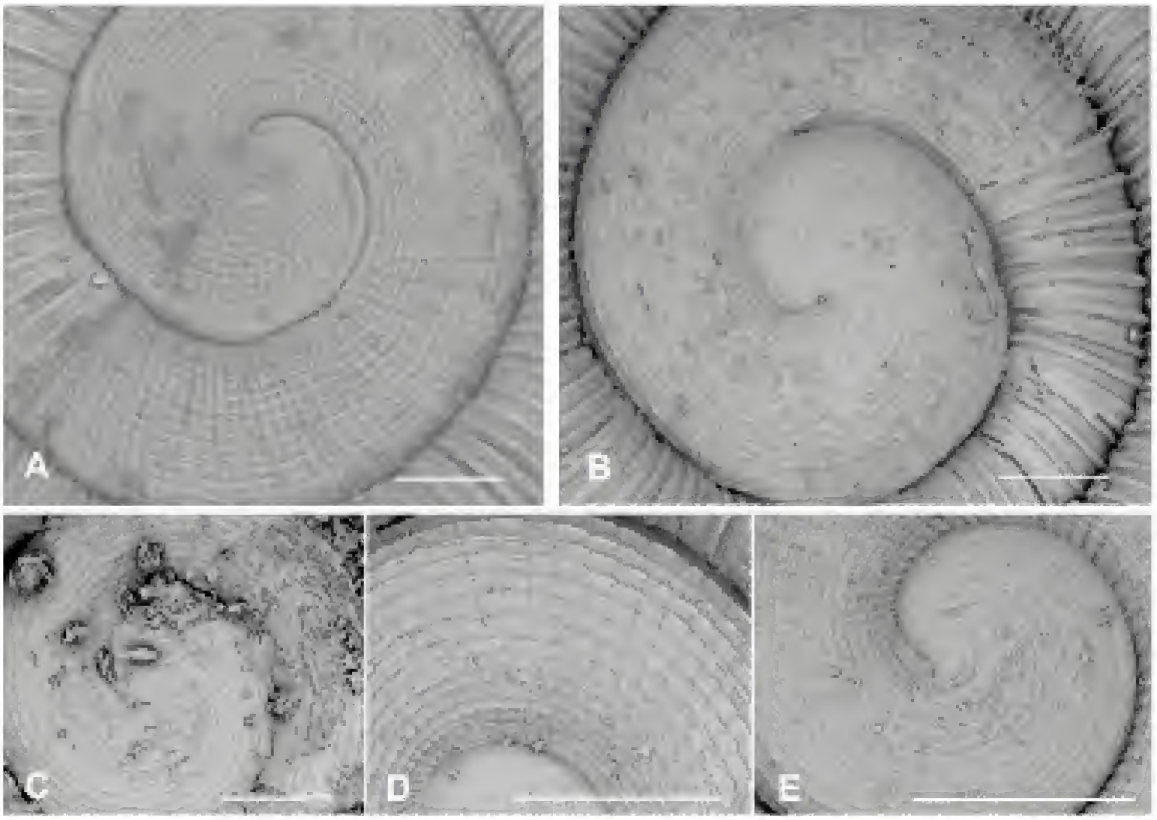
The charopid land snails of MEQ include a number of tiny species that have finely cancellate protoconchs (Holcroft 2018a). The generic assignment of these species that have broadly similar finely cancellate protoconch sculpture relies heavily on conchological features such as shell microsculpture (protoconch and teleoconch) and general shell features (spire protrusion, umbilical width, coiling pattern). Emphasis on shell morphology has been necessitated by the lack of suitable material for molecular analyses and anatomical dissection.

The shared finely cancellate protoconch sculpture of these genera is visible by optical microscopy but the differences between the

FIG. 12. Dorsal and ventral views of holotypes of *Isolderopa* species. **A,** *I. iangallowayi,* QMMO13102, SW of Calen Charlton, MEQ; **B,** *I. minuta,* QMMO13445, Eungella NP, MEQ; **C,** *I. deliqua,* QMMO13101, SW Calen, MEQ; **D,** *I. teemburra* sp. nov., QMMO35809, Endeavour Ck, MEQ; **E,** *I. whitsunday* sp. nov., QMMO11902, Cape Hillsborough, MEQ; **F,** *I. diamante* sp. nov., QMMO86546, Diamond Cliffs, MEQ. Images: Geoff Thompson, QM.

FIG. 13. Dorsal and ventral views of the holotypes of *Tristanoropa* gen. nov. species. **A,** *T. hughesae* sp. nov., QMMO85130, Mt Charlton, MEQ; **B,** *T. conwayensis* sp. nov., AMSC154891, Brandy Creek, MEQ. Images: Geoff Thompson, QM.

FIG. 14. Finely cancellate protoconch sculpture of SEQ and NEQ charopids. **A,** Webbed variant of *Shearopa offordae,* QMMO85145, Yeppoon, SEQ; **B,** Scalloped variant of *Shearopa magnetica,* QMMO78975, Magnetic Island, NEQ; **C,** Spiral pattern with finely cancellate pattern emerging after 1 whorl of *Excaliburopa leroii* Stanisic, 2010, QMMO79893, Undara Crater, NEQ; **D,** Webbed variant of Charopid WT41, QMMO73854, Bakers Blue Mt., FNQ; **E,** Webbed variant of Charopid MQ53 from Byfield NP, MEQ. Scale bars = 100 µm.



genera are subtle and discernible only by SEM. However, shell coiling pattern and spire protrusion provide two general shell characters by which the genera may be distinguished.

The nautiloid coiling pattern of *Pereduropa* and *Isolderopa* is similar but the genera differ in that *Pereduropa* species feature a flat to slightly raised spire while those of *Isolderopa* have a biconcave shell and depressed spire. *Tristanoropa* differs from both by having a tight multi-whorled shell and a flat spire. *Isolderopa* is the only one of the three genera that includes species with apertural barriers, although they are absent in some *Isolderopa* species.

From the evidence available, all three genera appear endemic to MEQ. Investigation of species in the neighbouring regions of SEQ and NEQ considered other taxa with a finely cancellate protoconch sculpture: *Shearopa offordae* Stanisic, 2010 from Yeppoon, SEQ, *S. magnetica* Stanisic, 2010 from Magnetic Island, NEQ, *Excaliburopa leroii* Stanisic, 2010 from Undara Crater, NEQ, Charopid WT41 from Bakers Blue Mt., NEQ and Charopid MQ53 from Byfield NP, SEQ. Each of these species demonstrated significant variation in the finely cancellate protoconch pattern from that found in MEQ species (Fig. 14). The webbed variant displayed by *S. offordae*, Charopid WT41 from Bakers Blue Mt, WT and Charopid MQ53 from the Byfield area, SEQ, separate these species from any in MEQ. The strongly spiral protoconch sculpture in the first protoconch whorl of *E. leroii* is also a factor distinguishing this species from all MEQ species. *Shearopa magnetica* has a similar protoconch sculpture to the MEQ species but the protoconch has more spiral cords (>20) than any MEQ species. It can also be distinguished from all MEQ species by having apertural barriers with numerous lamellae, three to four parietal outside the apertural edges and seven to eight internal palatals (Stanisic *et al.* 2010) unlike any *Isolderopa* species.

At the species level, protoconch diameter is a characteristic that appears to be uniform within each species (Appendix), and thus may be useful for species differentiation within charopids. Investigation of a wider range of species will be needed to confirm that this measurement is as instructive as it appears in differentiating the species in the three genera treated here.

The distribution of the 12 species of MEQ charopids with a finely cancellate protoconch documented in this study centres around the moist rainforests of the Eungella NP and surrounds and the drier araucarian rainforests of the coastal uplands of the Conway Range and Mt Dryander NPs. Species are also found in similar dry rainforests on many of the Whitsunday Islands. Unlike the larger *Gyrocochlea*-grade charopid species of MEQ (Holcroft 2018b), species of *Pereduropa* and *Isolderopa* are known from Cape Hillsborough, MEQ.

Of note, the type species of *Pereduropa* (*P. cursacosta*) has only been found south of Proserpine in the Clarke-Connors Range sub-region as well as in two coastal locations (Fig. 15). *Pereduropa delicata* is known from north of Proserpine and also in the Conway and Mt Dryander NPs. *Pereduropa hamiltoniana* is endemic to the Whitsunday islands and *P. burwelli* to the Eungella plateau.

Isolderopa shares a comparable distribution to that of *Pereduropa* (Fig. 16). *Isolderopa iangallowayi*, *I. minuta* and *I. deliqua* are endemic to the Clarke-Connors Range. *Isolderopa teemburra* is endemic to the Crediton SF in the environs of Teemburra Creek and its tributaries, viz. Endeavour Creek and Cherry Tree Creek. *Isolderopa diamante* is endemic to the Diamond Cliffs, Homevale NP and *I. whitsunday* to the Whitsunday region.

Tristanoropa has two species with very localised distributions, *T. conwayensis* endemic to the Conway Range and *T. hughesae* endemic to Eungella NP (Fig. 17). No species of *Tristanoropa* have been described from any of the Whitsunday islands. However, several undescribed specimens in the QM collection from South Molle Island and Gloucester Island may also be members of this genus. Further undescribed single specimens from St Helen's Beach and another from Hazelwood Gorge near the Eungella Dam may also be new *Tristanoropa* species.

FIG. 15. Map of localities *Pereduropa* species based on material examined. Species are identified by the following symbols: ■ *Pereduropa cursacosta*; ▲ *Pereduropa delicata*; ● *Pereduropa hamiltoniana*; ✸ *Pereduropa burwelli* sp. nov.

FIG. 16. Map of localities *Isolderopa* species based on material examined. Species are identified by the following symbols: ■ *Isolderopa iangallowayi*; ▲ *Isolderopa minuta*; ● *Isolderopa deliqua*; ▼ *Isolderopa teemburra* sp. nov.; ✸ *Isolderopa whitsunday* sp. nov.; ◆ *Isolderopa diamante* sp. nov.

While *I. iangallowayi*, *I. minuta* and *I. deliqua* appear to live in close proximity on the Eungella plateau, congeneric sympatry in charopids is highly unusual (Shea *et al.* 2012). The aforementioned three species occur in the higher altitude rainforests of Eungella NP. It may well be that these tiny snails live in tiny pockets of this extensive rainforest as no two have been found in exactly the same location (microsympatrically). However, further collecting particularly of live material allowing for DNA analysis will be necessary to understand this complex scenario.

The distribution of several species across the Clarke-Connors Range and Whitsunday subregions alludes to an historically widespread distribution of these tiny charopids prior to the aridification of the continent and contraction of rainforest in the Miocene (Kemp 1981). Ancient distributions would have been fractured with possible subsequent local species extinctions resulting in the current disjunct pattern for *Isolderopa minuta*. The land clearing of the Mackay-Proserpine lowlands in recent history may have contributed to loss of species in the areas between these two major areas of rainforest.

This study has a major emphasis on shell morphology. It is recommended that future collecting focus on animal tissue suitable for

FIG. 17. Map of localities *Tristanoropa* gen. nov. species based on material examined. Species are identified by the following symbols: ■ *Tristanoropa hughesae* sp. nov.; ▲ *Tristanoropa conwayensis* sp. nov.

molecular and anatomical analyses so that a more comprehensive systematics, combining DNA sequence data and morphological information, can enhance our understanding of these tiny MEQ charopids and thus provide a more integrative taxonomy.

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LITERATURE CITED

Bureau of Meteorology. 2017. Climate statistics for Australian locations. Available online at http://www.bom.gov.au (Accessed on 4 January 2018).

Holcroft, L. 2018a. Protoconch sculpture as a taxonomic tool in Australian charopid systematics (Gastropoda: Eupulmonata: Charopidae). *Molluscan Research*, https://doi.org/10.1080/13235818.2017.1409069.

Holcroft, L. 2018b A revision of *Gyrocochlea*-grade Charopidae from mid-eastern Queensland and redescription and generic reassignment of three *Gyrocochlea*-grade species (Eupulmonata: Charopidae). *Memoirs of the Queensland Museum - Nature* **61**. https://doi.org/10.17082/j.2204-1478.61.2018.2017-14.

Hyman, I.T. & Stanisic, J. 2005. New charopid landsnails, chiefly from limestone outcrops in eastern New South Wales (Eupulmonata: Charopidae). *Memoirs of the Queensland Museum* **50**: 219-302.

Kemp, E.M. 1981 Tertiary paleogeography and the evolution of Australian climate. *In*, A. Keast (ed.), *Ecological Biogeography of Australia*, pp. 32–49. W. Junk Publishers: The Hague, Netherlands.

Shea, M., Colgan, D. & Stanisic, J. 2012. Systematics of the landsnail genus *Gyrocochlea* and relatives (Mollusca: Charopidae). *Zootaxa* 3585: 1–109.

Solem, A. 1983. Endodontoid land snails from Pacific Islands (Mollusca: Pulmonata: Sigmurethra). Part II. Families Punctidae and Charopidae, Zoogeography. (Field Museum: Chicago).

Stanisic, J. 1990. Systematics and biogeography of eastern Australian Charopidae (Mollusca: Pulmonata) from sub-tropical rainforests. *Memoirs of the Queensland Museum* **30**: 1–241.

Stanisic, J. 1998. Family Charopidae. Pp. 1097–1099 *In*, Beesley, *P.* L., Ross, G. J. B. & Wells, A. (eds) *Mollusca: The Southern Synthesis. Fauna of Australia.* Vol. 5. CSIRO Publishing: Melbourne, Part B viii, 565–1234pp.

Stanisic, J. 2016. Two new species of Pinwheel Snail from Queensland and a redescription and generic

reassignment of *Gyrocochlea myora* Stanisic, 2010 (Gastropod: Eupulmonata: Charopidae). *Memoirs of the Queensland Museum–Nature* **60**: 1–12 https://doi.org/10.17082/j.2204-1478.60.2016.2016-07.

Stanisic, J., Shea, M., Potter, D. & Griffiths, O. 2010. *Australian Land Snails Volume 1: A Field Guide to Eastern Australian Species*. (Bioculture Press: Mauritius) 596pp.

APPENDIX. Species measurements for adult specimens used in this study. Diameter (D), Height (H), Umbilical width (U), Aperture Height (AH), Aperture width (AW), Protoconch diameter (PD) in mm. Protoconch length is measured in the number of whorls. H/D and D/U are ratios. The number of ribs on the first whorls of the teleoconch (T1) and the number of ribs in the third quadrant of the body whorl (WWB) are counts.

Species	Reg #	D	H	U	AH	AW	PD	WWB	T1	H/D	D/U	# Whorls	PL
Pereduropa cursacosta	QMMO78972	2.30	1.23	0.82	0.98	0.82	0.41	38	56	0.54	2.80	4.125	1.5
	QMMO78972	2.13	1.31	0.82	0.82	0.74	0.41	30	44	0.62	2.60	4.125	1.5
	QMMO78972	2.46	1.31	0.74	1.07	0.90	0.41	37	48	0.53	3.33	4.500	1.5
	QMMO19993	2.54	1.48	0.82	0.90	0.98	0.41	27	48	0.58	3.10	4.125	1.5
	QMMO11901	2.30	1.39	0.74	0.98	0.82	0.41	23	47	0.61	3.11	4.125	1.5
	QMMO11901	2.21	1.23	0.82	0.90	0.82	0.41	22	49	0.56	2.70	4.000	1.5
	QMMO85127	2.46	1.31	0.90	0.98	0.90	0.41	28	60	0.53	2.73	4.125	1.5
	QMMO85133	2.46	1.48	0.90	0.90	0.90	0.41	26	45	0.60	2.73	4.250	1.5
	MEAN	2.36	1.34	0.82	0.94	0.86	0.41	29	50	0.57	2.89	4.17	1.50
Pereduropa delicata	QMMO35547	1.72	0.98	0.74	0.82	0.74	0.41	35	82	0.57	2.33	4.000	1.5
	QMMO78971	2.05	0.98	0.90	0.82	0.66	0.41	31	78	0.48	2.27	4.250	1.5
	QMMO78971	1.80	1.07	0.74	0.82	0.74	0.41	32	68	0.59	2.44	4.250	1.5
	AMSC154896	2.05	1.15	0.57	0.98	0.82	0.41	25	67	0.56	3.57	4.375	1.625
	AMSC154896	2.21	1.23	0.74	0.90	0.82	0.41	29	79	0.56	3.00	4.875	1.5
	AMSC154896	2.13	1.23	0.82	0.90	0.82	0.41	32	76	0.58	2.60	4.500	1.5
	AMSC154896	2.13	1.15	0.74	0.74	0.66	0.41	25	62	0.54	2.89	4.500	1.5
	MEAN	2.01	1.11	0.75	0.85	0.75	0.41	30	73	0.55	2.73	4.39	1.52
Pereduropa hamiltoniana	QMMO78970	1.80	1.07	0.57	0.90	0.66	0.41	15	44	0.59	3.14	4.250	
	QMMO78970	1.89	1.15	0.66	0.74	0.57	0.41	17	44	0.61	2.88	4.375	1.5
	QMMO78970	1.89	1.07	0.66	0.82	0.57	0.41	16	42	0.57	2.88	4.375	1.625
	QMMO78970	1.89	0.98	0.66	0.82	0.66	0.41	17	45	0.52	2.88	4.250	
	QMMO60585	1.89	1.15	0.57	0.90	0.66	0.41	19	45	0.61	3.29	4.250	1.625
	QMMO86089	2.05	1.07	0.74	0.82	0.82	0.41	18	42	0.52	2.78	4.375	1.5
	MEAN	1.90	1.08	0.64	0.83	0.66	0.41	17	44	0.57	2.97	4.31	1.56
Pereduropa burwelli	QMMO6372	2.21	1.31	0.49	0.98	0.82	0.49	35	117	0.59	4.50	4.375	1.875
	QMMO85105	2.38	1.48	0.66	1.07	0.82	0.49	40	107	0.62	3.63	4.500	1.75
	QMMO85103	2.38	1.48	0.57	1.07	0.98	0.49	42	99	0.62	4.14	4.250	1.5
	QMMO6369	2.05	1.23	0.57	0.90	0.82	0.49	26	78	0.60	3.57	4.125	1.625
	QMMO6369	2.13	1.15	0.74	0.90	0.74	0.49	37	99	0.54	2.89	4.250	1.75
	QMMO6369	2.13	1.15	0.66	0.90	0.74	0.49	34	82	0.54	3.25	4.250	1.75
	AMSC154908	2.54	1.48	0.66	1.15	0.98	0.49	45	109	0.58	3.88	4.500	1.625
	AMSC154899	2.30	1.15	0.57	0.98	0.90	0.49	38	116	0.50	4.00	4.250	1.75
	QMMO13075	2.13	1.15	0.74	0.98	0.82	0.49	34	75	0.54	2.89	4.000	1.625
	QMMO6355	2.21	1.31	0.66	0.98	0.90	0.49	39	112	0.59	3.38	4.25	1.625
	QMMO11759	2.46	1.48	0.74	1.15	0.82	0.49	46	75	0.60	3.33	4.375	1.625
	QMMO6374	2.05	0.98	0.66	0.90	0.74	0.49	36	102	0.48	3.13	4.125	1.75
	QMMO6374	2.05	1.15	0.66	0.90	0.74	0.49	39	97	0.56	3.13	4.125	1.75
	QMMO42392	2.21	1.23	0.74	1.07	0.82	0.49	37	72	0.56	3.00	4.125	1.625
	QMMO6365	2.13	1.15	0.66	0.90	0.74	0.49	32	98	0.54	3.25	4.250	1.625
	MEAN	2.21	1.24	0.66	0.98	0.83	0.49	37	93	0.56	3.37	4.22	1.66

Appendix continued …

Species	Reg #	D	H	U	AH	AW	PD	WWB	T1	H/D	D/U	# Whorls	PL
Isolderopa iangallowayi	AMSC140446	1.89	1.15	0.66	0.98	0.74	0.33	42	94	0.61	2.88	5.000	1.75
	AMSC140446	1.80	1.15	0.74	1.07	0.74	0.33	40	88	0.64	2.44	5.000	1.5
	AMSC140446	2.13	1.31	0.74	1.07	0.74	0.33	47	106	0.62	2.89	5.125	1.675
	QMMO85131	1.97	1.15	0.66	0.98	0.82	0.33	56	107	0.58	3.00	5.250	1.5
	QMMO50891	1.89	1.23	0.74	1.07	0.74	0.33	40	93	0.65	2.56	5.375	1.75
	QMMO78962	1.80	1.07	0.74	0.90	0.66	0.33	50	90	0.59	2.44	5.250	1.75
	QMMO78962	1.89	1.15	0.74	0.98	0.74	0.33	55	103	0.61	2.56	5.250	1.75
	QMMO78962	1.80	1.07	0.74	0.98	0.66	0.33	72	120	0.59	2.44	5.000	1.675
	QMMO50880	1.72	1.15	0.66	0.98	0.66	0.33	45	97	0.67	2.63	5.000	1.675
	QMMO50880	1.56	1.15	0.66	1.07	0.66	0.33	42	104	0.74	2.38	4.875	1.75
	QMMO50885	1.97	1.23	0.66	1.15	0.74	0.33	51	120	0.63	3.00	5.250	1.75
	QMMO50885	1.89	1.15	0.74	1.07	0.66	0.33	52	109	0.61	2.56	5.250	1.675
	QMMO86088	1.89	1.15	0.66	0.98	0.66	0.33	48	119	0.61	2.88	5.250	1.75
	QMMO86088	1.89	1.15	0.66	0.98	0.66	0.33	44	102	0.61	2.88	5.250	1.75
	MEAN	1.86	1.16	0.70	1.02	0.70	0.33	49	104	0.62	2.68	5.15	1.69
Isolderopa minuta	QMMO78980	1.39	0.82	0.66	0.74	0.41	0.25	56	129	0.59	2.13	4.500	1.675
	QMMO78980	1.31	0.82	0.66	0.74	0.66	0.25	56	116	0.63	2.00	4.500	1.675
	QMMO50886	1.31	0.74	0.66	0.66	0.57	0.25	61	120	0.56	2.00	4.375	1.5
	QMMO50886	1.48	0.82	0.66	0.74	0.66	0.25	63	132	0.56	2.25	4.250	1.675
	QMMO85100	1.56	0.90	0.74	0.74	0.41	0.25	63	112	0.58	2.11	4.675	1.5
	QMMO85077	1.31	0.82	0.57	0.74	0.49	0.25	43	122	0.63	2.29	4.250	1.675
	QMMO85087	1.39	0.90	0.66	0.66	0.41	0.25	60	127	0.65	2.13	4.500	1.75
	QMMO85106	1.23	0.66	0.57	0.57	0.41	0.25	65	124	0.53	2.14	4.000	1.75
	QMMO85085	1.48	0.82	0.66	0.66	0.41	0.25	67	132	0.56	2.25	4.375	1.625
	QMMO85137	1.64	0.90	0.66	0.74	0.57	0.25	58	124	0.55	2.50	4.750	1.75
	MEAN	1.41	0.82	0.65	0.70	0.50	0.25	59	124	0.58	2.18	4.42	1.66
Isolderopa deliqua	QMMO78960	1.97	1.07	0.82	0.82	0.74	0.33	40	110	0.54	2.40	4.750	1.625
	QMMO78960	1.72	0.98	0.82	0.82	0.66	0.33	41	115	0.57	2.10	4.125	1.625
	QMMO6354	2.05	1.23	0.74	0.90	0.66	0.33	37	90	0.60	2.78	4.250	1.625
	QMMO6354	1.80	1.23	0.74	0.90	0.57	0.33	36	111	0.68	2.44	4.250	1.625
	QMMO6354	1.64	0.90	0.82	0.90	0.57	0.33	29	99	0.55	2.00	4.000	1.625
	QMMO9725	1.97	1.07	0.82	0.90	0.66	0.33	45	102	0.54	2.40	4.500	1.625
	QMMO9725	2.13	1.15	0.82	1.07	0.66	0.33	43	97	0.54	2.60	4.500	1.625
	QMMO9725	1.97	1.15	0.82	0.90	0.66	0.33	39	87	0.58	2.40	4.500	1.625
	QMMO13452	1.97	1.15	0.82	0.90	0.57	0.33	36	87	0.58	2.40	4.375	1.625
	QMMO13452	2.21	1.15	0.82	0.98	0.66	0.33	36	101	0.52	2.70	4.750	1.5
	QMMO85132	2.05	1.07	0.82	0.90	0.74	0.33	37	102	0.52	2.50	4.500	1.75
	MEAN	1.95	1.10	0.80	0.91	0.65	0.33	38	100	0.57	2.43	4.41	1.625
Isolderopa teemburra	QMMO35809	2.05	1.23	0.90	0.90	0.66	0.33	42	122	0.60	2.27	4.375	1.75
	QMMO86547	1.97	1.07	0.98	0.90	0.66	0.33	46	110	0.54	2.00	4.500	1.625
	QMMO86547	1.89	1.07	0.90	0.82	0.74	0.33	48	125	0.57	2.09	4.375	1.75
	MEAN	1.97	1.12	0.93	0.87	0.68	0.33	45	119	0.57	2.12	4.42	1.71
Isolderopa whitsunday	QMMO6348	1.64	0.82	0.66	0.74	0.49	0.33	55	129	0.50	2.50	4.250	1.5
	QMMO6348	1.80	0.90	0.66	0.74	0.49	0.33	57	121	0.50	2.75	4.500	1.5
	QMMO6348	1.72	0.82	0.66	0.74	0.41	0.33	55	129	0.48	2.63	4.500	1.5
	QMMO13089	1.56	0.90	0.66	0.74	0.49	0.33	51	117	0.58	2.38	4.625	1.5
	QMMO86548	1.48	0.82	0.66	0.74	0.49	0.33	48	114	0.56	2.25	4.375	1.625
	QMMO86548	1.56	0.82	0.66	0.74	0.41	0.33	50	117	0.53	2.38	4.625	1.625
	QMMO11902	1.64	0.90	0.74	0.74	0.41	0.33	51	120	0.53	2.38	4.125	1.5
	AMSC154890	1.64	0.90	0.74	0.74	0.41	0.33	59	116	0.55	2.22	4.625	1.5

Appendix continued …

Species	Reg #	D	H	U	AH	AW	PD	WWB	T1	H/D	D/U	# Whorls	PL
Isolderopa whitsunday cont…	QMMO74081	1.48	0.82	0.66	0.74	0.41	0.33	51	126	0.55	2.22	4.250	1.5
	QMMO65835	1.56	0.82	0.66	0.74	0.41	0.33	51	122	0.53	2.38	4.375	1.625
	QMMO60586	1.56	0.90	0.66	0.74	0.49	0.33	50	112	0.58	2.38	5.000	1.5
	QMMO85128	2.05	0.90	0.90	0.74	0.49	0.33	52	108	0.44	2.27	4.125	1.5
	QMMO85128	1.89	0.90	0.90	0.74	0.49	0.33	63	108	0.48	2.09	4.875	1.5
	QMMO85128	1.80	0.90	0.74	0.74	0.49	0.33	53	111	0.50	2.44	4.875	1.5
	QMMO68647	1.64	0.82	0.66	0.74	0.49	0.33	54	130	0.50	2.50	4.500	1.625
	QMMO85138	1.64	0.82	0.66	0.74	0.49	0.33	51	117	0.50	2.50	4.625	1.625
	QMMO85138	1.56	0.82	0.66	0.74	0.41	0.33	50	111	0.53	2.38	4.375	1.625
	QMMO85138	1.72	0.82	0.66	0.74	0.49	0.33	51	112	0.48	2.63	4.500	1.5
	MEAN	1.66	0.86	0.70	0.74	0.46	0.33	53	118	0.52	2.40	4.51	1.54
Isolderopa diamante	QMMO77078	1.39	0.90	0.57	0.82	0.49	0.33	36	102	0.65	2.43	3.875	1.75
	QMMO77078	1.56	0.90	0.66	0.82	0.66	0.33	37	107	0.58	2.38	4.000	1.75
	QMMO77078	1.56	0.90	0.66	0.82	0.66	0.33	37	107	0.58	2.38	4.000	1.75
	QMMO77078	1.56	0.90	0.66	0.82	0.66	0.33	37	107	0.58	2.38	4.000	1.75
	QMMO86071	1.56	0.90	0.74	0.82	0.49	0.33	39	104	0.58	2.11	4.000	1.625
	QMMO77078	1.72	1.15	0.74	0.90	0.57	0.33	41	114	0.67	2.33	4.250	1.625
	QMMO77078	1.48	0.82	0.66	0.74	0.49	0.33	45	117	0.56	2.25	3.750	1.5
	MEAN	1.55	0.93	0.67	0.82	0.57	0.33	39	108	0.60	2.32	3.98	1.68
Tristanoropa conwayensis	AMSC154891	1.64	0.98	0.66	0.74	0.57	0.33	33	75	0.60	2.50	4.500	1.625
	AMSC154891	1.89	1.07	0.74	0.74	0.66	0.33	37	73	0.57	2.56	4.875	1.5
	AMSC154891	1.72	0.98	0.66	0.74	0.57	0.33	33	70	0.57	2.63	4.675	1.5
	AMSC154891	1.64	1.07	0.66	0.74	0.66	0.33	34	86	0.65	2.50	4.500	1.5
	AMSC154891	1.56	0.90	0.66	0.74	0.49	0.33	33	75	0.58	2.38	4.375	1.5
	AMSC154891	1.89	0.98	0.57	0.82	0.74	0.33	30	69	0.52	3.29	4.250	1.5
	QMMO85336	1.89	1.23	0.66	0.74	0.66	0.33	39	90	0.65	2.88	5.250	1.625
	QMMO85336	1.64	0.98	0.74	0.57	0.66	0.33	40	96	0.60	2.22	4.500	1.5
	MEAN	1.73	1.02	0.67	0.73	0.63	0.33	35	79	0.59	2.62	4.62	1.53
Tristanoropa hughesae	QMMO13099	1.72	0.82	0.66	0.74	0.57	0.41	62	111	0.48	2.63	4.625	1.5
	QMMO13099	1.72	1.07	0.57	0.90	0.66	0.41	55	112	0.62	3.00	4.500	1.625
	QMMO85136	1.89	0.98	0.74	0.90	0.66	0.41	59	104	0.52	2.56	4.750	1.5
	QMMO50905	1.64	0.98	0.66	0.74	0.66	0.41	50	115	0.60	2.50	4.725	1.5
	QMMO50887	1.72	0.98	0.66	0.74	0.66	0.41	60	112	0.57	2.63	5.000	1.5
	QMMO50892	1.56	0.90	0.66	0.66	0.66	0.41	52	104	0.58	2.38	4.875	1.5
	QMMO50881	1.39	0.82	0.57	0.66	0.57	0.41	49	105	0.59	2.43	4.675	1.5
	MEAN	1.66	0.94	0.64	0.76	0.63	0.41	55	109	0.57	2.59	4.74	1.52